LEAR SIEGLER, INC.

CIMRON DIVISION

# TRAINING SEMINAR

## CIMRON MODELS 6653A & 6753

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# TRAINING SEMINAR

# CIMRON MODELS 6653A & 6753

Section I 6653A

Section II 6753

Section III General Information

7-16-69 to 7-17-69

TCB/sb

MODEL 6653 A

DIGITAL VOLT-RATIO METER

MEDIUM SPEED A/D

## GENERAL INTRODUCTION

The new and improved Cimron Model 6653A was designed as a high quality laboratory measurement instrument with the versatility and speed required for systems applications. It is not intended to be a "Cheapy" 4-digit instrument. A review of the enclosed specifications illustrates this design philosophy. The accuracy is stated over a period of six months and through a usable (25°C ± 5°C) temperature range. Such things as input impedance, common mode rejection, normal mode rejection, and functional control have not been sacrificed.

The Model 6653A is a high-speed, (one millisecond digitize time) integrated circuit, Digital Volt-Ratio Meter. Successive approximation logic is employed to attain the speeds required of computer peripheral equipment. A detailed technical discussion is included in the instrument manual.

You will notice we are continuing the excellence in packaging that has come to be expected of Cimron instruments. By removing one screw and the small vinyl panel, "L" brackets may be secured for standard 19-inch rack mounting. Removal of two more screws and the larger vinyl panels reveal the Extrusions, prebored to accept a wide variety of rack-mounting slide rails.

## OPERATING CONTROLS

The fron panel has incorporated the simplicity of push button controls, designed to be as self-explanatory as possible.

### RATE SWITCH

Adjustable encoding rate 1-5 readings per second.

### POWER SWITCH

On/Off

### FILTER

Out - No Filter
Med - 32 db @ 60 HZ
Full - 70 db @ 60 HZ

### FUNCTION

Remote - Allows Remote Programming of all front penel controls.
DC - Selects DC Function.
mV/DC - Allows autorange operation from mV to DC if the autorange board is in the instrument and the autorange button is in.
mV - Selects mV function.
AC - Selects AC function.
KΩ - Selects KΩ function.
Ratio - Selects DC ratio for either (-):(-) or +:(-) ratios.

### RANGE

| DC | AC | MV | RATIO | K | REM |
|---|---|---|---|---|---|
| | IV | | | 1K | 1 |
| 10V | 10V | 10mV | 1:1 | 10K | 2 |
| 100V | 100V | 100mV | 10:1 | 100K | 3 |
| 1K | 1KV | 1KmV | 100:1 | 1M | 4 |
| | | | | 10M | 5 |

Auto - Allows automatic ranging of the function selected by the function switch.

PRINT

Print Off - Enables DVM to measure input signals without issuing printouts. This switch must be depressed when printouts are not desired or when DVM does not have printout assemblies installed.

Print Auto

Depressed - Enables printout after each conversion.

Print Hold Disables DVM to enable force print.

Print Force Generates one encoding and causes one print command to be generated after encode completion. DVM then returns to hold.

SIGNAL

Hi - High side of signal input.
Lo - Low side of signal input. (isolated from ground)
Guard - Equipment Guard Shield

ZERO

mV - Zero Adjustment for preamplifier. Allows offset for thermals.
KΩ - Zero Adjustment for Ohms Converter. Allows compensation for lead resistance.

FUNCTION

(Upper left of Front Panel) Indicates function selected by function switch, and indicates whether or not that function card is in the instrument.

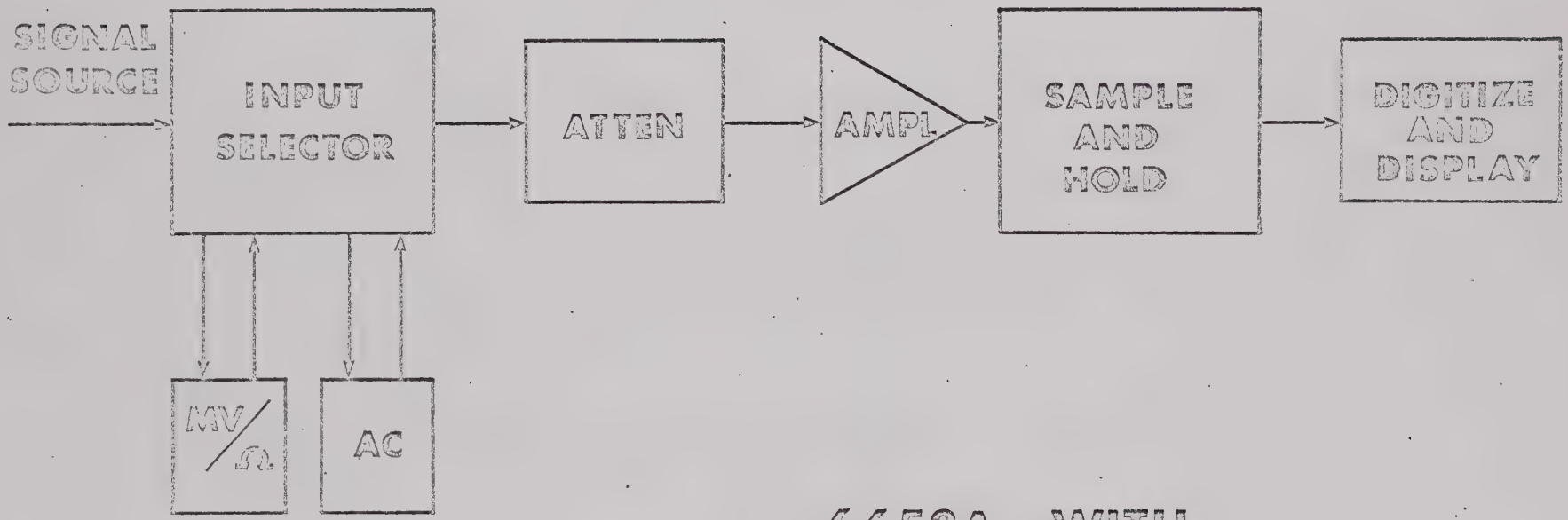
## PLUG-IN ACCESSORIES

The basic instrument is expandable to a complete multimeter by the addition of plug-in cards. The input selector, Option#1, is required to operate either the AC Converter or the Millivolts/Ohms Converter. Autoranging, sample and hold, remote control, and various options of print output are also contained on individual plug-in cards providing ease in troubleshooting and maintenance.

The print-out options will interface with a variety of output devices and, combined with the DTL output for direct computer interface, provide excellent versatility.

Economies realized by combining Millivolts and Ohms on one card allow more economical multimeter applications. Three ranges of millivolts, including a 10-mV full scale range, and 5 ranges of resistance are available on the Model 5689 card. Model 5676 AC Converter provides four ranges: 1.0999, 10.999, 109.99, and 1099.9 VAC at 50 Hz to 100 K Hz. One autoranging plug-in card provides autoranging for all functions, including MV-DC. When plugged in, the converters are within the box-within-a-box construction maintaining the isolated differential input feature.

The Sample and Hold option is one of the latest additions to the 6653A list of flexible extensions.
Detailed specifications are outlined on the technical data sheet. To give you an idea of its operating mode look at Figure 5, which shows typical Sample and Hold technique. The Sample and Hold module follows the input amplifier, so all functions can be used in the Sample & Hold mode. The aperture time is only 50 nsec, so 50 nsec samples of a changing input can be taken at rates up to 1K Hz. The Sample & Hold module can be gated remotely, and so its sample time can be selected for specific points on the input waveform, or to avoid noise sources with known timing.




6653A WITH SAMPLE AND HOLD

FIGURE 5

# TECHNICAL DESCRIPTION

Model 6653A Digital Volt-Ratio Meter

The digital feedback loop sketched in Figure 1 helps to clarify the logic of the 6653A. It shows how the analog voltage from the input amplifier is compared to the analog voltage from the digital-to-analog voltage converter (D/A). The comparator does not measure the size of the difference between the two voltages; it indicates only the polarity. That is, the comparator determines only which of the two signals is larger. The logic network incrementally decreases or increases the output of the D/A as indicated by the comparator.

The loop is committed to the single task of keeping the comparator input equal to zero. The two analog signals are of opposite polarity, and because the two comparator input resistors are equal, when the two voltages are equal in magnitude though opposite in sign, the comparator input is zero.

The logic network includes a set of storage flip-flops that keep a record of the actions required to null the comparator input. These same flip-flops supply a stable digital input to the D/A converter to maintain the comparator null, and they also can supply the same digital number to a NIXIE display for an operator.

The logic network can take many forms. The logic technique used in the 6653A is called "successive approximation." It is a "single pass" scheme; that is, a prescribed sequence of events, requiring a fixed time interval, is used to make each measurement. The measuring time is independent of the analog input magnitude or polarity.

Figure 2 illustrates the digitizing of a voltage by the successive approximation

technique. The example voltage is +5.500 volts, indicated by the dashed line across the top of the figure. The botton waveform shows the output of a comparator error amplifier that has unity gain and inverts. At the end of the sequence, the comparator error amplifier output is zero. At the beginning of the sequence, the comparator indicates errors of decreasing amplitudes and changing polarities. The middle waveform in Figure 2 shows the output of the digital-to-analog converter. The converter output is added to the 5.500 volt input to obtain the error. For example, when the sequence begins, the D/A output is zero, so the error is equal to the +5.500 volt input. The comparator error amplifier inverts and is also limited to 5 volts, so the error amplifier output is -5.000 volts. This error causes the D/A output to increase in a negative direction to offset the positive input.

The code in the 6653A is 1-2-4-8 Binary-coded-decimal. The bit having the greatest weight is tested first, and the output of the D/A drops to -8 volts. While this change is in the right direction, it is too large by 2.5 volts, so the error amplifier output changes polarity and indicates +2.5 volts. The logic network removes the too-large 8-weighted bit and tries the 4-weighted bit. This restores the error momentarily to the -5 level, but as the 4-weighted bit is added, the error becomes -1.5 volts. This indicates that this change in the D/A output was in the right direction, but too small. The 4-weighted bit therefore remaines as the 2-weighted bit is tested. This testing proceeds until all the bits have been tried. Because there are four decimal decades in the 6653A display and four binary flip-flops in each decade, a total of 16 steps is the necessary minimum. One added step not shown in Figure 2 is the polarity test. Another

step is needed to signal for a range change (autorange option only), and in all, 20 steps are used by the 6653 to encode any voltage. The entire sequence requires 1 millisecond.

Figure 3 is a block diagram of the basic 6653A. The digital feedback loop can be detected in the diagram if the polarity change is temporarily ignored and the logic network is identified as the decades and program control.

The polarity changer is a unity-gain inverting amplifier that is used to make the apparent analog input to the comparator always positive. The D/A then has to provide only negative voltages. When the input to the 6653A is positive, the polarity changer is inactive and shunted by a parallel resistor. When the input is negative, the polarity changer provides a positive output current that is exactly twice the magnitude of the negative current through the resistor. The net input current to the comparator is therefore positive and can be balanced by the negative feedback current from the D/A.

The attenuator is a set of wirewound resistors that provide relay-selected attenuation factors of 1.0, 0.1, and 0.01. In the 10 volt range, no shunt resistors are used, and so the input impedance depends only upon the input amplifier. In the 100 and 1000 volt ranges, the input impedance is greater than 10 megohms.

The filer consists of two relay-selected active filters.

The input amplifier is a non-inverting potentiometric device having unity gain.

Its purpose is to present a very high impedance to the source and a very low output impedance to the comparator. The input impedance is greater than 10,000 Megohms. This enormous impedance is maintained at dc and for both input polarities because the input stage is a pair of field effect transistors. These require no bias current from the source, in contrast to the dc current required to bias input transistor stages. The settling time of the amplifier is about 300 microseconds.

The polarity changer and the error amplifier, which is part of the comparator, are integrated circuit amplifiers. The comparison device which follows the error amplifier is also an integrated circuit.

The program control unit provides a sequence of 20 timing pulses to perform the successive approximation. This unit, as well as all other logic functions, is comprised of integrated circuits. Program control pulses are routed to the decades board.

The D/A is a matched set of wirewound resistors controlled through transistor switches by the decades. A precision voltage reference followed by a reference amplifier provides the stable dc voltage that is divided by the D/A as commanded by the decades. An external voltage can be used as reference (selected by a front panel switch) to measure the ratio of two voltages.

The 6653A with plug-in options is shown in Figure 4. The basic instrument requires no modification to accept the full line of multimeter options. These include autorange, remote control of all functions, ohms converter, preamplifier,

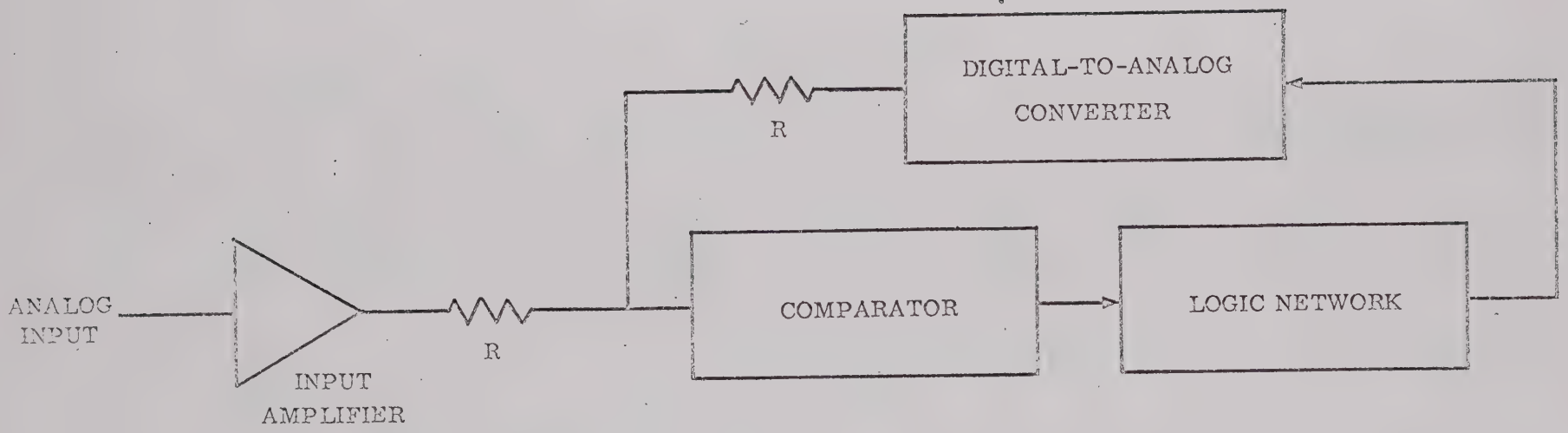
ac converter, and print output in five configurations.

The converters are new solid-state designs that make full use of new technologies to produce simpler and more reliable units. The ohms converter and dc preamplifier are available as a single unit on one 9-inch printed circuit card. The ac converter occupies a separate 9-inch card. Adding the first converter requires adding the input selector card in addition to the converter card.

The autorange option provides automatic ranging from the most sensitive millivolt range through the 1000 volt range. All the logic required for this option is added by installing one 9-inch circuit card.

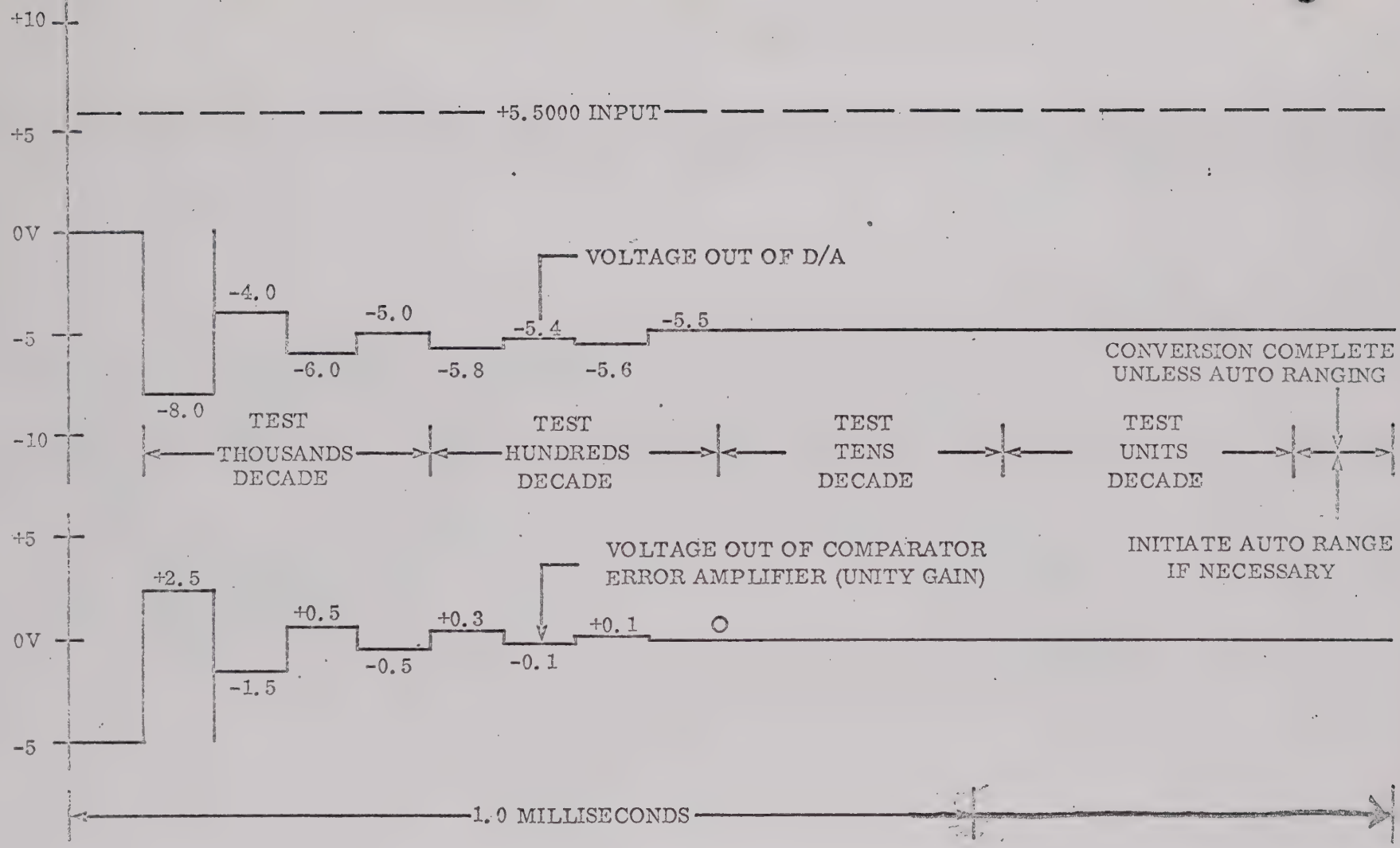
Remote control consists of two 7-inch cards. One 7-inch card provides remote control of the start pulse, reference selection, decimal locations and range. A second 7-inch card provides remote control of all functions and of print output. The remote function is available in two versions, buffered and unbuffered. The buffered remote option provides entry to the DVM only through isolated reed relay contacts, so guard and ground isolation are preserved. The unbuffered version is less costly for those applications not requiring isolation.

Print output is available in a 10-line code or a BCD code. Both print output codes are available in a contact closure version for isolation and in a voltage state version where isolation is not required. The 10-line output requires three 9-inch cards plus the print control card. The BCD output requires two 9-inch cards plus the print control card.




DIGITAL FEEDBACK LOOP

Figure 1




SUCCESSIVE APPROXIMATION

Figure 2

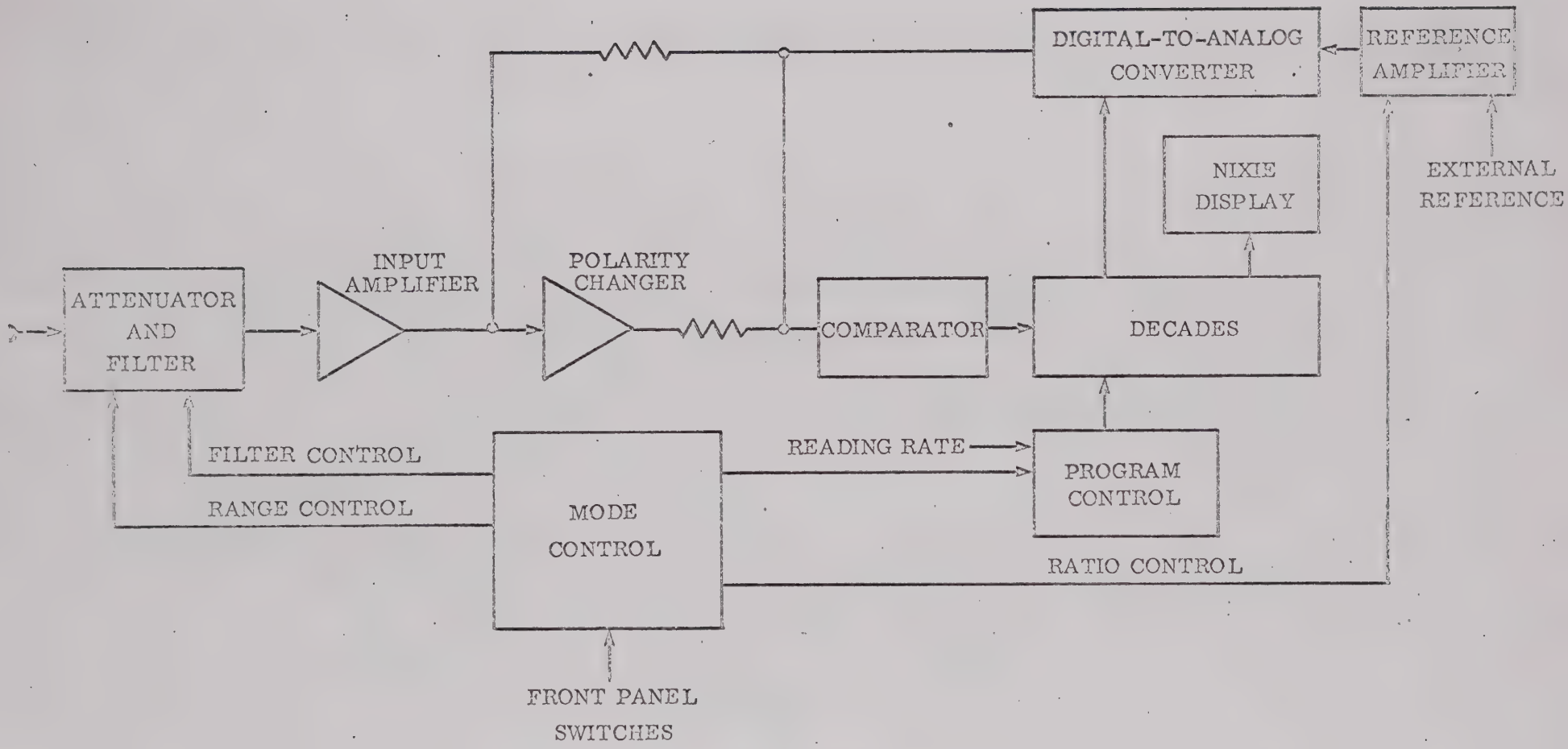

DIGITAL-TO-ANALOG CONVERTER
REFERENCE AMPLIFIER
NIXIE DISPLAY
EXTERNAL REFERENCE
ATTENUATOR AND FILTER
INPUT AMPLIFIER
POLARITY CHANGER
COMPARATOR
DECADES
FILTER CONTROL
RANGE CONTROL
MODE CONTROL
READING RATE
PROGRAM CONTROL
RATIO CONTROL
FRONT PANEL SWITCHES

Figure 3

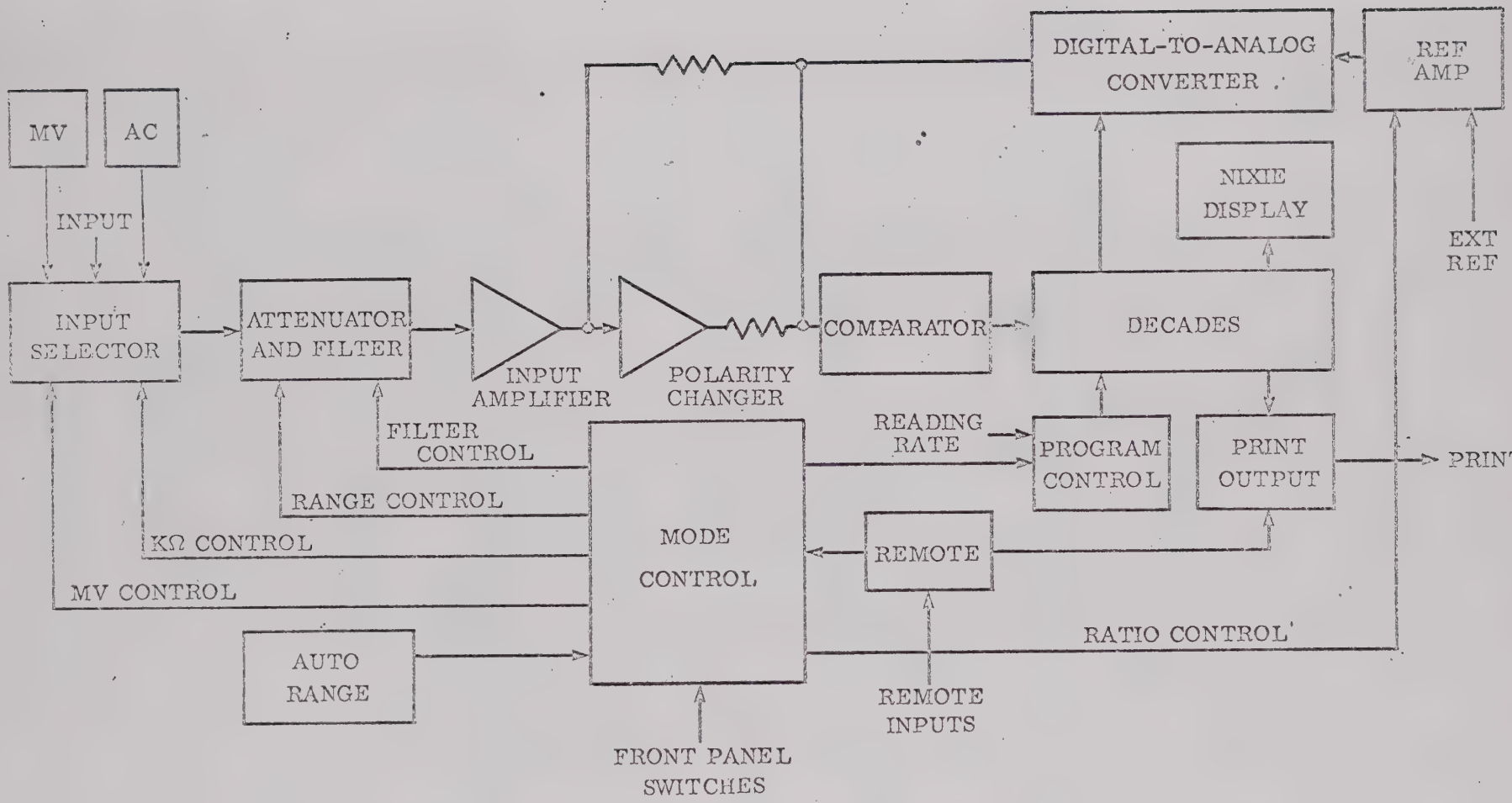

MV
AC
INPUT
INPUT SELECTOR
ATTENUATOR AND FILTER
INPUT AMPLIFIER
POLARITY CHANGER
COMPARATOR
DIGITAL-TO-ANALOG CONVERTER
REF AMP
NIXIE DISPLAY
EXT REF
DECADES
FILTER CONTROL
RANGE CONTROL
KΩ CONTROL
MV CONTROL
MODE CONTROL
READING RATE
PROGRAM CONTROL
PRINT OUTPUT
PRINT
REMOTE
RATIO CONTROL
AUTO RANGE
REMOTE INPUTS
FRONT PANEL SWITCHES

Figure 4

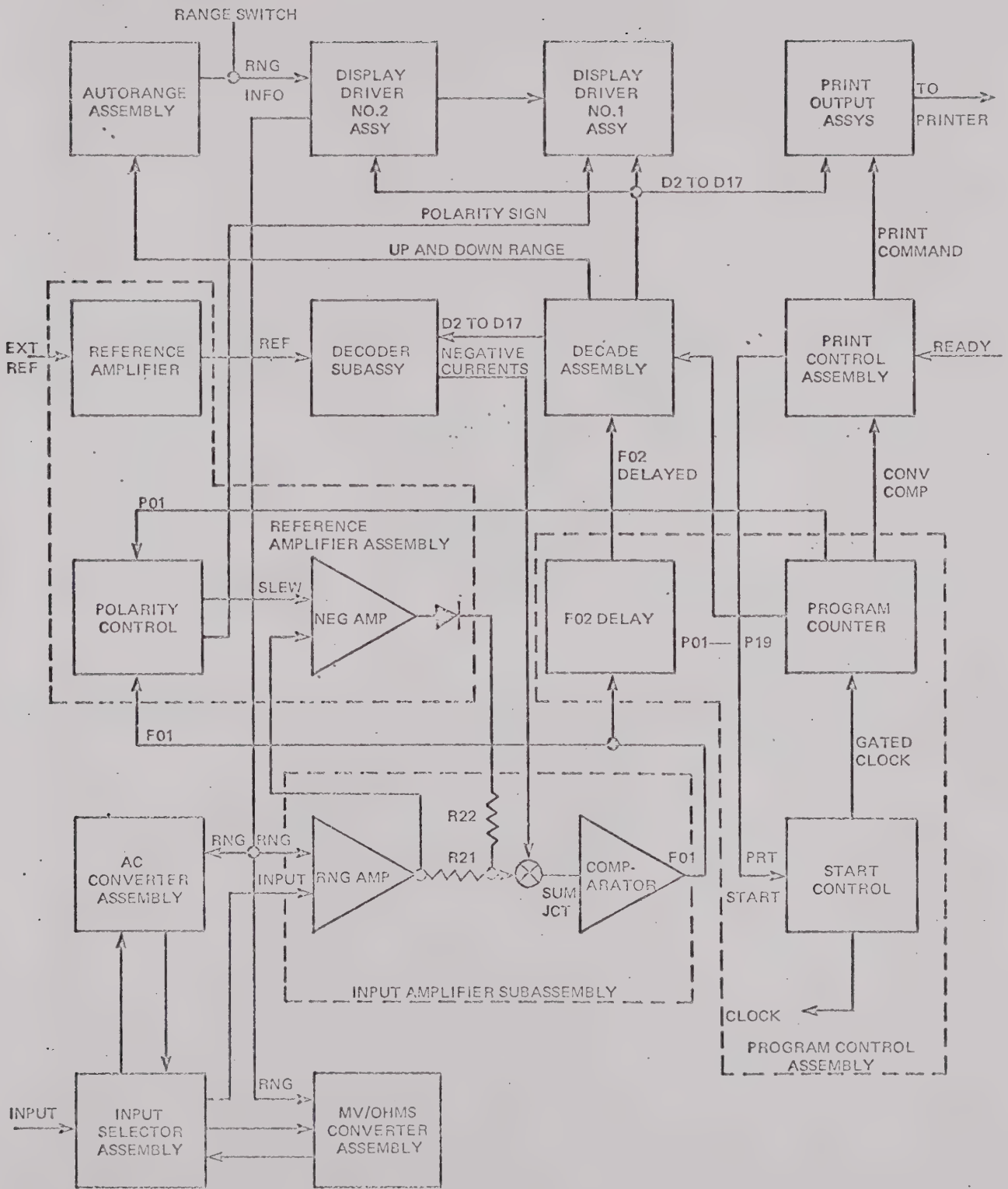



Figure 5-2. Model 6653A Block Diagram.

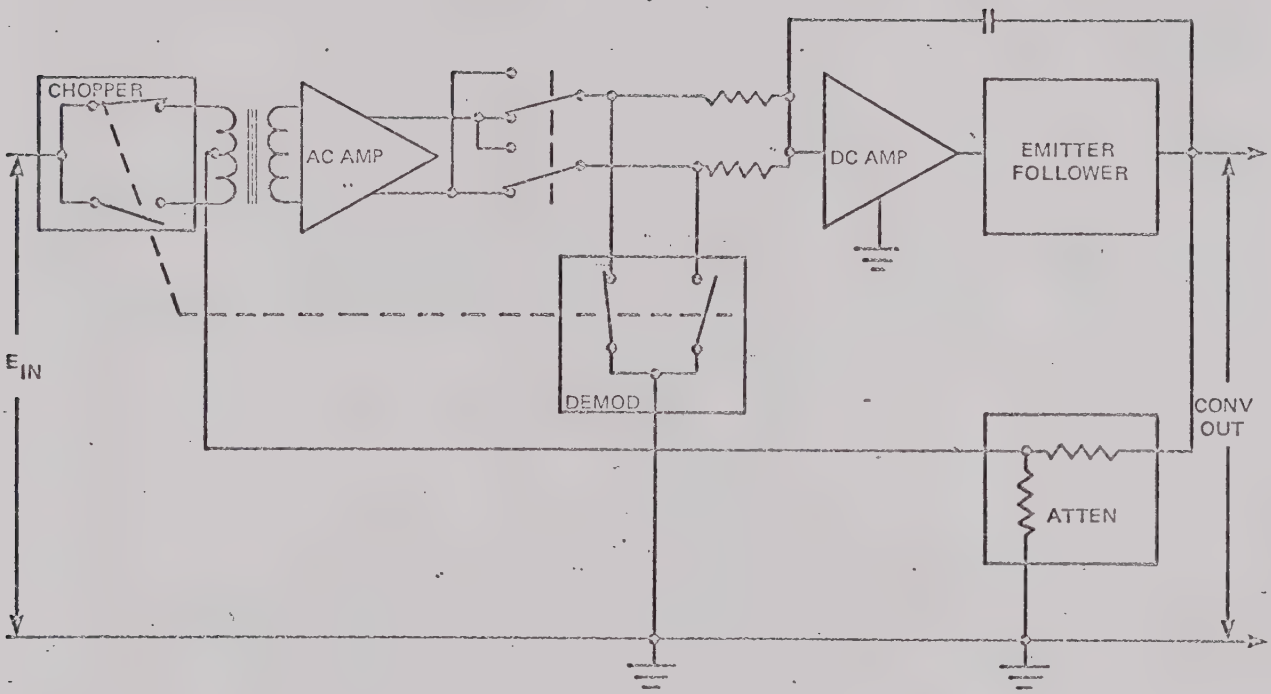



Figure 5-3. Millivolt Measurement Configuration.

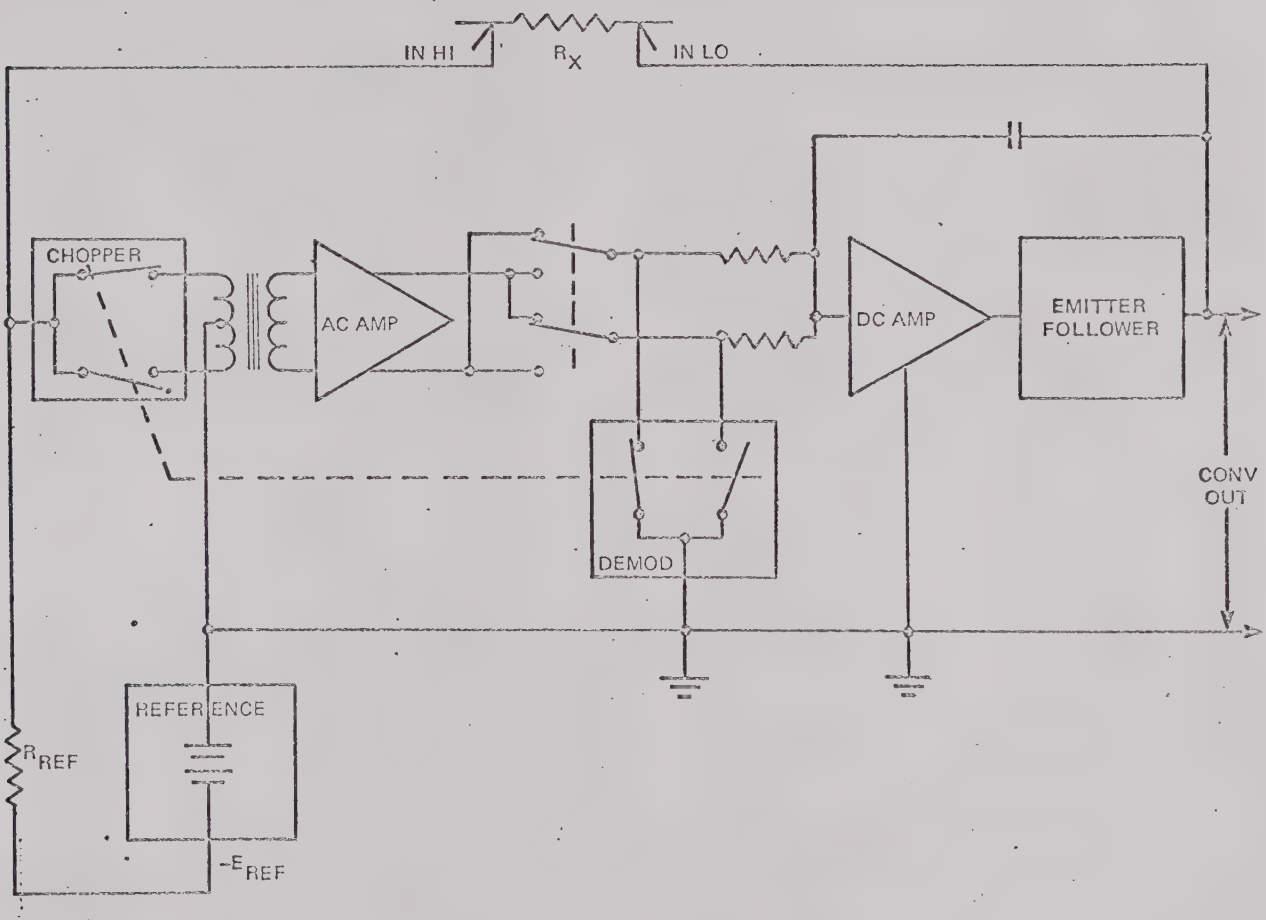



Figure 5-4. Resistance Measurement Configuration.

## PRINT OUTPUT

Print output information is available either in voltage-state form or by means of contact closures. The information can be provided as 10 line decimal (contact closure only) or 1-2-4-8 BCD output.

The instrument can be operated in one of two print modes. In Print Mode 1 no printout delays are provided and maximum printing speed results. For Mode 1, the External Start Pulse and DTL Print Output Assemblies are used. In Print Mode 2, the normal mode, the Print Control Assembly and either the 10-Line, or 1-2-4-8 BCD Print Output Assemblies are required.

In Print Mode 1 (figure 5-8), when $\overline{\text{EXT START CONT}}$ is programmed from the remote control unit the instrument will lock up. With each EXT START PULSE from the remote control unit, the instrument will take a single reading and then lock up. P20/Conversion Complete is the print command. If the instrument is in AUTO-RANGE, an External Start Pulse is required for each range change.

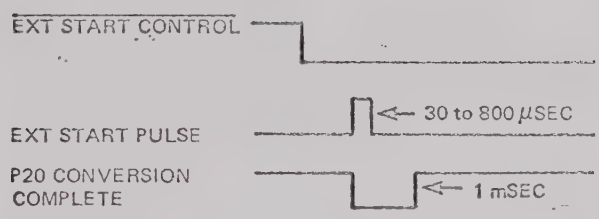



Figure 5-8. Print Mode 1 Operation.

In Print Mode 2 the print timing sequence is controlled by the Print Control Assembly. Figure 5-9 shows the sequence of events for single print operation.

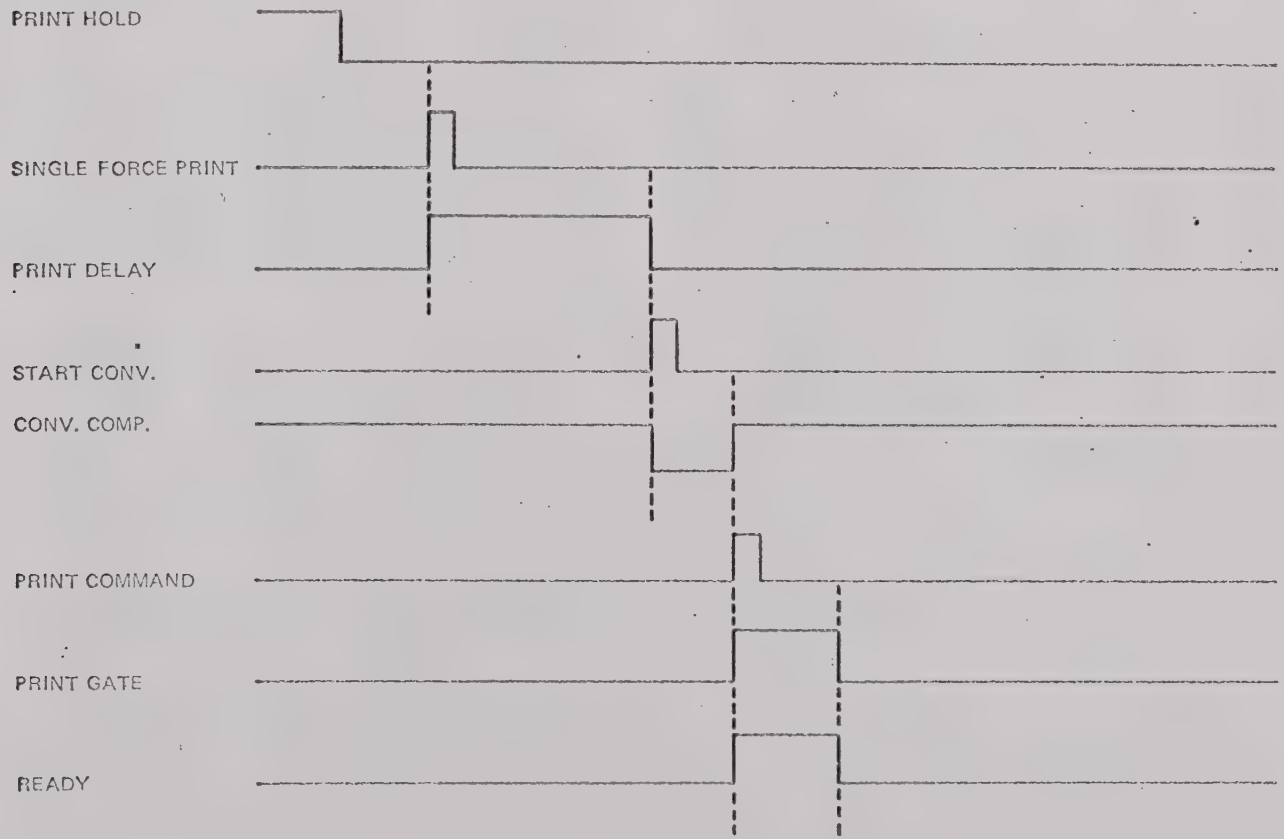



Figure 5-9. Print Mode 2, Single Print.

First, Print Hold and then Force Print Commands are programmed from the remote control unit. The Force Print Command starts a 3-phase print operation. During phase one the Print Control Assembly generates a Print Delay Command to allow the instrument to settle. At the end of the delay period, which is adjustable for DC V, AC, KΩ, or MV modes of operation and FILTER FULL operation; phase two commences. In phase two the Print Control Assembly issues Start Conversion and Conversion Complete commands. The commands enable the instrument to take a single measurement and then lock up. Phase three, the print phase, then starts. The Print Control Assembly generates Print Command and Print Gate signals. The Print Command enables the associated recording device to print. The Print Gate signal closes the instrument print output reeds, making the printout information available to the recording device. The Ready signal is generated by the recording device upon completion of the recording device print cycle. The Ready signal resets the Model 6653A. Until the Ready signal is received, no further measurements can be made.

In Print Mode 2 with AUTO PRINT, the 3-phase print operation is repetitive (figure 5-10).

The READY signal (6) from the associated recording device provides the SINGLE PRINT PULSE (1) that initiates the delay (instrument settling) phase. The delay time can be adjusted between minimum and maximum values as follows:

| MODE OF OPERATION | MIN. TIME | MAX. TIME |
|---|---|---|
| DC V | 50 MSEC | 400 MSEC |
| MV, AC, KΩ | 100 MSEC | 800 MSEC |
| FILTER FULL | 100 MSEC | 3 SEC |

The minimum delay times are dictated by the instrument's requirements to properly function when in autoranging and medium filter.

The DELAY COMPLETE (2) results in START CONVERSION (3). In the conversion phase, the time from START CONVERSION to CONVERSION COMPLETE (4) is 1 millisecond. Providing range change pulses are not present at the Print Control Assembly, when conversion has been completed the Print Control initiates a PRINT COMMAND (5) to the associated recording device. In the print phase, the elapsed time between PRINT COMMAND and READY signal (6) is variable and depends on the characteristics of the recording device.

When range change pulses are present at the Print Control Assembly during CONVERSION COMPLETE (4), the Print Control will not issue a PRINT COMMAND. It will issue, instead, a SINGLE PRINT PULSE that restarts the delay phase.

When the instrument is in AUTORANGE one SINGLE PRINT PULSE will suffice regardless of the number of range changes.

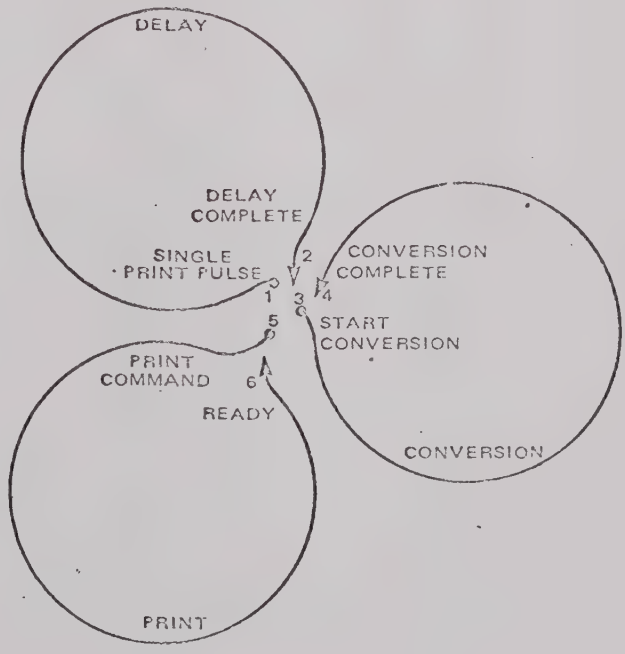
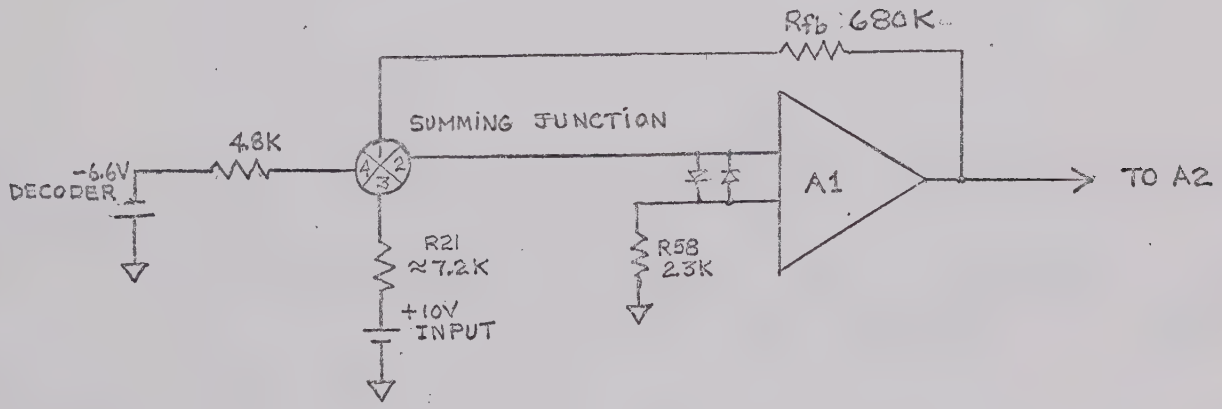
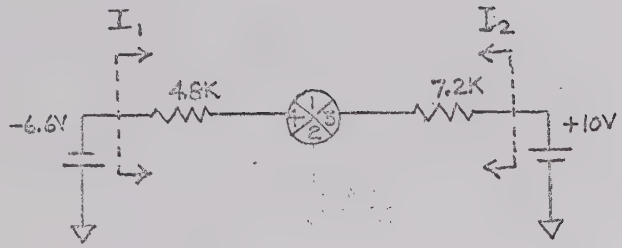



Figure 5-10. Print Mode 2, With Auto Print.

# 6653 COMPARATOR AMPLIFIER
## (Part of Input Amp. Assy.)

ASSUME: 1. D.V.M. READING +10V
2. INPUTS SHOWN AS THEVININ EQUIVALENTS

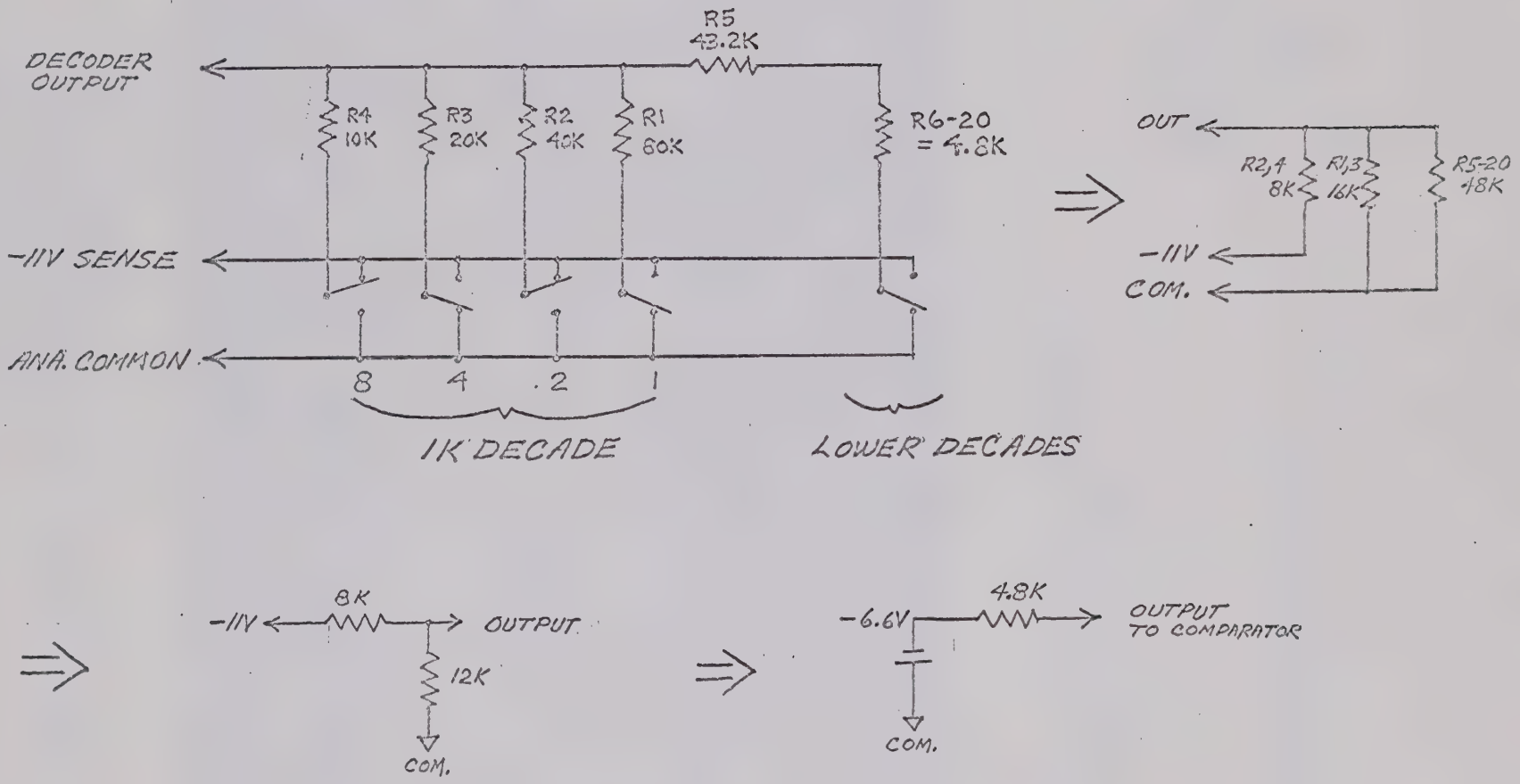



Sum of $I_1 + I_2 = \boxed{0}$

# 6653 DECODER (VOLT-CUR. LADDER)
## Equivalent circuit - 10 count 1K

ASSUME: 1. D.V.M. Reading + 10V
2. ALL SOLID STATE REPRESENTED BY SWITCHES.
3. ALL RESISTORS IN LOWER DECADES AT GROUND, (R6-20).




TCB
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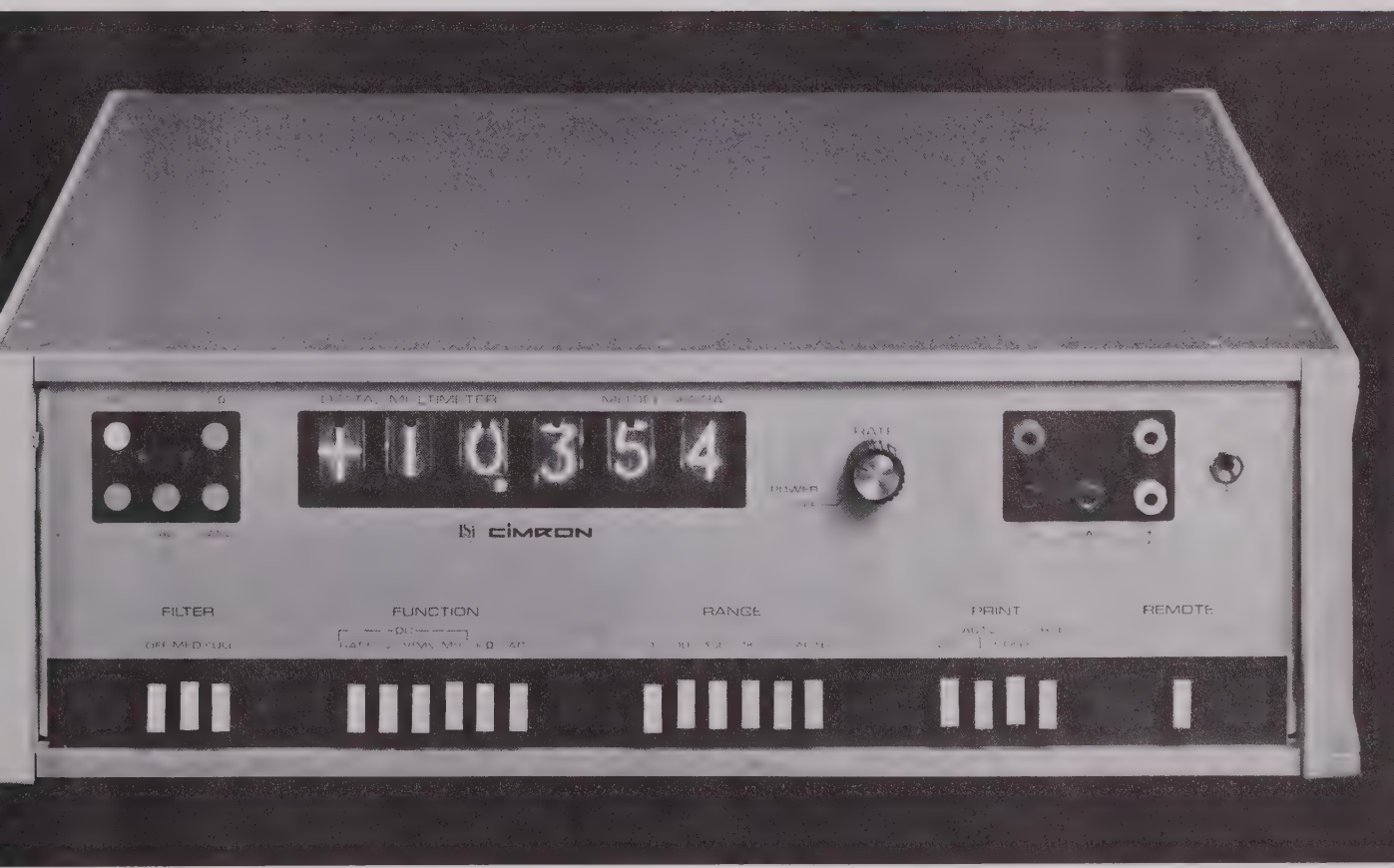
CIMRON

# MODEL 6653A
# DIGITAL MULTIMETER




**FEATURES:**

- ALL IC S.A. LOGIC
- 1 KHz READING RATE
- AC, DC, DC RATIO, MILLIVOLT AND OHMS MEASUREMENT
- AUTOMATIC POLARITY
- SAMPLE AND HOLD OPTION
- FIVE PRINT OPTIONS
- AUTORANGING FOR ALL FUNCTIONS
- FULL REMOTE PROGRAMMABILITY
- ±1 DIGIT ACCURACY
- PUSHBUTTON CONTROLS

## DESCRIPTION

The Cimron Model 6653A Digital Multimeter meets all the requirements for most applications, either as a laboratory instrument or for use in a digital data acquisition system. The basic 6653A is a 0.01% accurate DC voltmeter and ratiometer. Optional plug-in boards quickly add the functions of AC, millivolts and ohms. Other options include sample and hold and autoranging, which provide automatic ranging through all ranges of each function. For systems application, five print output options are available, both buffered and non-buffered. The instrument is remotely programmable for all front panel controls and functions.

The 6653A has been built to Cimron's consistent standard of superior quality. Excellent isolation is created by box-within-a-box case construction, with all calibrating controls and test points easily accessible through the top guard shield. Functional interior layout has drastically reduced the amount of wiring, thereby assuring greater reliability and consistent performance. Integrated circuits are used throughout the instrument. Front panel pushbutton switches are mounted directly on the printed circuit board, which eliminates hand wiring and the attendant possibility of conductor breakage. Unique spring-loaded handles may be extended for carrying or retracted for flush mounting in a rack.

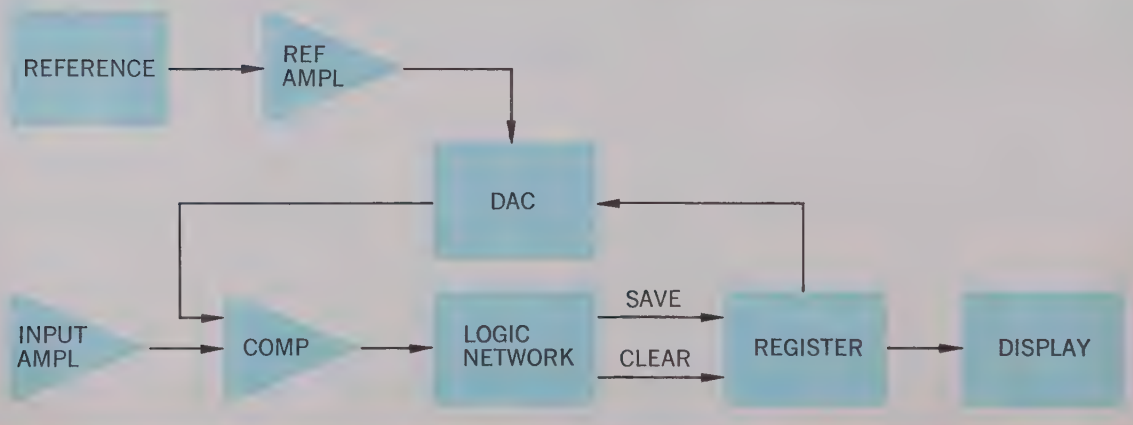
## LOGIC

The sampling rate of the 6653A is achieved through the use of an advanced linear amplifier with unusually short settling times and an IC successive approximation logic design.

Successive approximation is a closed loop analog-to-digital conversion technique. The analog input is compared to an ultrastable internal reference in a sequence of events that begins with the receipt of a pulse from internal or external start control. As shown in Figure 1, the analog input, buffered by the input amplifier, is compared to the output of a solid state digital-to-analog converter. As the sequence begins, the most significant bit of the D/A is set and the output of the comparator determines whether that contribution is too large and should be reset, or too small and should be augmented to match the input. The next most significant bit is then set, and the comparator makes a new judgment. When all the bits have been tested and the comparator output nulled, the register is holding the digital equivalent of the analog input.

(Figure 1)

**SUCCESSIVE APPROXIMATION DVM BLOCK DIAGRAM**



CIMRON

# SPECIFICATIONS
# MODEL 6653A
# DIGITAL MULTIMETER

## SPECIFICATIONS — DC

**Ranges:** 0–±10.999V 0–±109.99V 0–±1099.9V

Ranges are manually selectable. The addition of an autorange option will enable automatic ranging for DC and ratio functions as well as autoranging for the AC and millivolt/ohms options. Remote options for control via voltage levels or contact closures

**Absolute Accuracy:** All ranges, 25°C ±5°C, no temperature coefficient

Short Term (30 days): ±0.01% of full scale (FS)

Long Term (6 months): ±(0.01% of FS + 0.01% of reading)

**Temperature Coefficient:** ±0.002% of FS/°C

**Response Time:** Digitizing with Polarity Change: 1 millisecond

Range Change: 50 milliseconds per range under external control. 200 milliseconds with front panel control of sample rate

Settling time for full scale step: (Filter out) 300 microseconds, (Med. Filter) 175 milliseconds, (Full Filter) 450 milliseconds

**Sample Rate:** Front panel adjustment: 1-5 samples per second including polarity change

External: Zero to 1 KHz

**Common Mode Rejection:** DC — 120 dB with 1 KΩ unbalance in either lead, filter out

AC — 100 dB at 60 Hz with 1000Ω unbalance in either lead, filter out

**Normal Mode Rejection:** Active Gaussian filters selectable via front panel or remote with option:

At 60 Hz — (Filter Out) none, (Filter Med.) 32 dB, (Filter Full) 70 dB

**Input Resistance:** At or off null:

10.999V range: 10,000 MEGΩ minimum
109.99 and 1099.9V ranges:
10 MEGΩ minimum

**Display:** Four decimal digits (plus fifth for 10% overrange) and polarity using long life Nixie* tubes behind non-reflecting polarizing screen

## DC/DC RATIOS

All DC specifications apply except the following:

**Ranges:** ±1.0999:1 ±10.999:1 ±109.99:1

**Polarity:** Automatic to allow ratio measurement of ± voltages to a minus reference voltage

## EXTERNAL REFERENCE: −1V to −10V

**Response Time:** Digitizing with polarity change = 1 millisecond

Range change = 50 milliseconds under external control and a minimum of 200 milliseconds from local control (Input Signal Only)

**Ratio Input Resistance:** 10 Megohms minimum

## MODEL 5676 AC CONVERTER

**Ranges:** 0–1.0999V 0–109.99V
0–10.999V 0–1099.9V

Ranges are manually selectable. Addition of autorange and/or remote option provides for autoranging and/or remote control

**Maximum Voltage Rating:** 50 Hz–50 KHz: 500V rms
50 KHz–100 KHz: 250V rms

**Absolute Accuracy:** All ranges 10°C–40°C

50 Hz–20 KHz:
±(0.05% of FS + 0.05% of reading)

20 KHz–50 KHz:
±(0.05% of FS + 0.2% of reading)

50 KHz–100 KHz:
±(0.05% of FS + 0.5% of reading)

**Temperature Coefficient:** 0.005% of FS/°C

**Response Time:** Digitizing: 1 millisecond
Range Change: 50 milliseconds (external control)

Settling Time (0.01%):
(No Filter) above 1 KHz, 40 milliseconds
(Med. Filter) above 100 Hz, 200 "
(Full Filter) above 50 Hz, 450 "

**Input Impedance:** 1 MEGΩ shunted by <100 picofarads, on all ranges

**Common Mode Rejection:** 60 Hz and less: 80 dB with 1 KΩ unbalance in either lead

## MODEL 5689 MV/OHMS CONVERTER*

### OHMS CONVERTER

**Ranges:** 0–1.0999 KΩ 0–1099.9 KΩ
0–10.999 KΩ 0–10999. KΩ
0–109.99 KΩ

**Absolute Accuracy:** 25°C ±5°C
Short Term (30 days):

1, 10, and 100 KΩ ranges:
±(0.01% of FS + 0.01% of reading)

1,000 KΩ range:
±(0.01% of FS + 0.03% of reading)

10,000 KΩ range:
±(0.03% of FS + 0.05% of reading)

*Burroughs Trademark

*Millivolt and ohms options are combined on one plug-in board.

# SPECIFICATIONS
# MODEL 6653A
# DIGITAL MULTIMETER

**OHMS CONVERTER** *(Continued)*

Long Term (6 months):
1, 10, and 100 KΩ ranges:
±(0.02% of FS+0.01% of reading)
1,000 KΩ range:
±(0.02% of FS+0.03% of reading)
10,000 KΩ range:
±(0.05% of FS+0.05% of reading)

**Temperature Coefficient:**
1, 10, and 100 KΩ ranges: 0.002% of FS/°C
1,000 KΩ range: 0.003% of FS/°C
10,000 KΩ range: 0.006% of FS/°C

**Maximum Voltage Across Unknown Resistance:**
20 V DC (out of range) Maximum current is 10 milliamperes on 1 KΩ range

**Response Time:**
Digitizing: 1 millisecond
Range Change: 50 milliseconds (external control)
Settling Time (to 0.01%):
1, 10, and 100 KΩ ranges: 75 milliseconds
1,000 KΩ range: 100 milliseconds
10,000 KΩ range: 750 milliseconds

**MILLIVOLTS PREAMPLIFIER**

**Ranges:**
0–±10.999 mV
0–±109.99 mV
0–±1099.9 mV

Ranges are manually selectable. Addition of autorange and/or remote option provides for autoranging and/or remote control. Autorange option allows for autoranging through all six mV and DC ranges

**Absolute Accuracy:**
25°C ±5°C
Short Term (30 days):
10.999 mV range:
±(0.02% of FS+0.02% of reading)
109.99 and 1099.9 mV ranges:
±(0.01% of FS+0.01% of reading)

Long Term (6 months):
10.999 mV range:
±(0.03% of FS+0.02% of reading)
109.99 and 1099.9 mV ranges:
±(0.02% of FS+0.01% of reading)

**Zero Stability:**
Less than 0.5 μV/°C after warmup

**Temperature Coefficient:**
10.999 mV range: 0.005% of FS/°C
109.99 and 1099.9 mV ranges: 0.004% of FS/°C

**Response Time:**
Digitizing: 1 millisecond
Range Change: 50 milliseconds (external control)
Settling Time (to 0.01%):
10.999 mV range: 350 milliseconds
109.99 and 1099.9 mV ranges: 60 milliseconds

**Input Resistance:**
10.999 mV range: 10 MEGΩ minimum
109.99 and 1099.9 mV ranges: 100 MEGΩ minimum

**Common Mode Rejection:**

| | DC | 60 Hz |
|---|---|---|
| 10.999 mV range: | 146 dB | 134 dB |
| 109.99 mV range: | 126 dB | 114 dB |
| 1099.9 mV range: | 106 dB | 100 dB |

**OPTIONS**

**Sample and Hold:**
Aperture Time = 50 Nanoseconds
Aperture Uncertainty = 100 Nanoseconds
Hold Decay = 1 MV/MS maximum
Input Impedance = Same as function selected
Accuracy = Add ±0.01% Full Scale to Basic Specification

**Print Outputs:**
Codes
1-2-4-8 = DTL Logic "0" = 0 Volts, "1" = +5 Volts
1-2-4-8 = Voltage Level "0" = −12 Volts, "1" = 0 Volts
1-2-4-8 = Voltage Level "0" = +12 Volts, "1" = 0 Volts
1-2-4-8 = Contact Closures (isolated)
10 lines = Contact Closures (isolated)

**Remote Control:**
Non-Buffered = Via voltage level ("0" = 0 Volts, "1" = +5 Volts) DTL
Buffered = Via isolated contact closures

Ranges, functions, print controls and external digitize commands can be externally controlled via 35 lines

**Autorange:**
See "Range" specification for each function

**GENERAL SPECIFICATIONS**

**Power Requirement:**
105–125 or 210–250 Volts, 50–60 Hz (400 Hz optional)

**Warmup:**
30 minutes to full accuracy

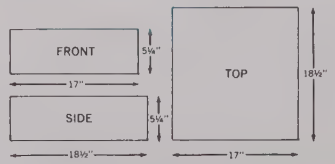
**Operating Temperature:**
0° to +50°C

**Warranty:**
12 months

**Dimensions:**
Height: 5¼" (13.34 Cm.)
Width: 17" (43.18 Cm.)
Depth: 18½" (46.99 Cm.)

**Net Weight:**
40 lbs. max.

**Shipping Weight:**
52 lbs. max.




*Specifications subject to change without notice.*

**NOTE:** All of the options are designed for plug-in field installation at any time without modification to the basic instrument. Output codes can be selected by changing plug-in cards, thus affording the user the flexibility of being able to drive several output devices with a single instrument. Further economy is realized by combining the ohms converter and millivolts converter on a single plug-in card.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20-011 6/69

# MODEL 6753

# DIGITAL MULTIMETER

# THE MODEL 6753 DIGITAL MULTIMETER

## GENERAL DESCRIPTION

The Model 6753 Digital Multimeter consists of a DC voltmeter and DC/DC volt-ratiometer basic instrument and optional accessories. The accessories, available in any combination are:

1. One AC Converter Assembly
2. One MV/Ohms Converter Assembly
3. One Input Selector Assembly. (Required with items 1 or 2.)
4. One Autorange Assembly
5. One Print Control Assembly
6. Two 10-line contact closure, or two 1-2-4-8 binary coded decimal (BCD) contact closure, or two 1-2-4-8 BCD voltage state, or two diode transistor logic (DTL) 1-2-4-8 BCD Print Output Assemblies
7. One Remote Assembly or Remote Buffer Assembly
8. Guarded Input Signal Cable Assembly in any desired number
9. Reference Voltage Cable Assembly in any desired number
10. One rear panel Signal Input Connector
11. Mounting hardware (bench stand, rack-mounting brackets, or slide rails)

With the exceptions of items 10 and 11, all optional accessories are the plug-in type.

## BASIC INSTRUMENT CAPABILITIES

The basic instrument can measure DC voltages and DC/DC voltage ratios. The instrument employs the continuous balance, or tracking, principle of operation. The instrument can:

1. Constantly track an input signal and provide a front panel readout either at any time upon command or automatically when a null is attained, or

2. Repetitively track the input signal for 60 milliseconds and provide a readout either at any time during the tracking interval upon command or automatically

at the end of the tracking interval. Upon completion of a readout, the instrument starts another 60 millisecond tracking cycle. When in repetitive track mode, the input signal sampling rate can be varied from one to five times per second.

Instrument measurement functions, sampling rates, ranges, tracking modes, sensitivity, and degree of input signal filtering can be selected manually by means of front panel controls. The instrument has a front panel display of five digits (six digits for 10% overrange), an input signal polarity indication, and a decimal point indication. The input signal polarity is detected automatically. Front panel lights indicate the instrument function that has been selected. When the instrument is in manual range and the input signal amplitude exceeds the upper range limits, a numeral 1 in the overrange window slowly and continuously blinks to indicate the reading is in error.

DC Voltage Measurement

The instrument can measure DC voltages from ±0.0001 to ±1099.99 volts in four full-scale ranges of 1.09999, 10.9999, 109.999 and 1099.99.

DC/DC Voltage Ratio Measurement

The instrument can measure either +DC/+DC or -DC/+DC voltage ratios. Ratio is measured by comparing an unknown DC input voltage of either polarity with a known external +DC reference voltage. The external reference voltage can be any value from +1 to +10 volts. The ratio range is from .00001:1 to 109.999:1 in four full scale ranges of .109999:1, 1.09999:1, 10.9999:1, and 109.999:1.

INSTRUMENT CAPABILITIES WITH ACCESSORIES

The Model 6753 with any or all of the optional accessories has the capabilities of the basic instrument. In addition, with appropriate accessories, the instrument can:

1. Measure AC voltages, low-level DC voltages (microvolts), DC voltages that vary from microvolts-to-volts-to-microvolts, and resistance

2. Automatically range through six ranges from millivolt values through DC values

3. Provide a print output to drive a recording device

4. Be remotely controlled

5. When remotely controlled:

   a. Sample the input signal from 0 to 10 times per second when in the repetitive tracking mode

   b. Measure the ratio of AC voltages or millivolts to a ÷DC external reference voltage.

Instrument measurement functions, sampling rates, tracking modes, sensitivity, degree of input signal filtering, and print modes can be manually or remotely selected. Ranging can be manually, automatically, or remotely controlled.

AC Voltage Measurement

With an AC Converter Assembly installed, the instrument can measure AC voltages over a frequency range of 50 hertz to 100 kilohertz. The instrument can measure voltages from 0.0001 to ~~1000~~ 750* volts in four full-scale ranges of 1.09999, 10.9999, 109.999, and 1099.99.

Millivolt and Resistance Measurement

With a Millivolt/Ohms Converter Assembly installed, the instrument can measure:

1. DC voltages from ±0.0001 to ±109.999 millivolts in two full scale ranges of 10.9999 and 109.999.

2. Resistance from 0.0001 to 10999.9 kilohms in five full-scale ranges of 1.09999, 10.9999, 109.999, 1099.99, and 10999.9. To minimize lead resistance, 4-wire measurement is used in the 1, 10, and 100 ranges and 2-wire measurement in the 1K and 10K ranges.

DC Millivolts-to-Volts-to-Millivolts Measurement

With Millivolt/Ohms Converter and Autorange Assemblies installed, the instrument can measure DC voltages varying in value from ±0.0001 millivolts to ±1099.99 volts to ±0.0001 millivolts. When the input signal exceeds 109.999 millivolts, the instrument will range up to the DC measurement mode. When the input signal decreases to less than 100 millivolts, the instrument will range down to the millivolt measurement mode.

* De-rate above 20KC

Autoranging

With an Autorange Assembly installed, the instrument can automatically select the range which provides maximum resolution of the input signal.

Print Output

The instrument can provide either 10-line decimal or 1-2-4-8 BCD print output, dependent on the type of Print Output Assemblies installed. The print output can be either a 0 to ±12 voltage state or contact closure, and provides five-digit numeral (six in over-range), range, polarity, and instrument function information. An internal, isolated power supply furnishes Print Output Assembly reference voltages.

Remote Control

The instrument can be controlled from a remote control unit through an optional Remote Assembly or Remote Buffer Assembly. If isolation between the remote control unit and the Cimron instrument is not required, the instrument can be controlled directly through rear panel connectors and a Remote Assembly. If isolation is required, the instrument can be controlled through rear panel connectors and isolated contact closures mounted on a Remote Buffer Assembly. An internal, isolated power supply furnishes voltages to the relay coils of the Remote Buffer Assembly.

AC Voltage or DC Millivolt Ratio Measurement

When remotely controlled, the instrument can measure ratios between input signals from AC voltage or DC millivolt sources and an external positive DC reference voltage. The front panel readout decimal location, however, must be controlled from the remote control unit. When measuring AC/+DC or MV/+DC ratios, the external reference voltage can be any value from +1 to +10 volts.

FABRICATION

The instrument is 5.25 inches high, 17.1 inches wide, 19.75 inches deep and fits a standard rack. The instrument is manufactured in accordance with the best commercial practices for material, parts, and workmanship.

The input signal leads are floating and isolated from the case, power line ground, and print output when print output is through isolated contact closures. A guard shield that may be driven externally is employed to ensure maximum input isolation and common mode rejection. Input may be floated up to 1000 volts DC or peak AC, provided the voltage

between any pin on the input connector and the instrument does not exceed 1500 volts peak.

Virtually all components are mounted on plug-in printed circuit boards, providing ease in troubleshooting and maintenance not usually encountered in complex electronic equipment.

Solid state components are used almost exclusively, including the digital potentiometer switches and converter chopper. Input signal attenuation, filter switching, and reference voltage switching are accomplished by means of reed relays.

# MODEL 6753 BASIC CIRCUIT THEORY

## GENERAL

## BASIC INSTRUMENT

### DC Measurement Mode

The basic instrument is essentially a closed loop servo system (figure 1). A stable, internally-generated reference voltage is connected across a series of narrow-tolerance resistors which comprise a precision resistance ladder. The logic of the instrument drives the resistance ladder until the sum of the incremental voltage steps equals the unknown input signal value. The front panel indicators display the incremental changes of the precision voltage as they are provided by the resistance ladder. When a state of balance between the sum of the precision voltage incremental changes and the unknown voltage value is attained, a null condition exists. The value displayed by the front panel indicators represents the unknown voltage value.

Resistance ladder drive is accomplished by the servo system activated by the difference sensed in a voltage comparison circuit. Voltage comparison is accomplished by a solid state comparator amplifier which compares the unknown voltage and the resistance ladder output. The comparator amplifier produces an output pulse that is proportional in amplitude to the difference between the two voltage values. From the comparator amplifier the error signals are directed to either the UP or DOWN logic drivers. The outputs of the drivers are directed by the control logic to the appropriate binary decade assemblies, causing the resistance ladder to null. Numeral indicators in the front panel indication monitor the position of the resistance ladder and indicate the decimal equivalent of the input voltage.

### DC/DC Ratio Mode

In the DC/DC ratio mode, the instrument compares an unknown DC input signal voltage with a known external DC reference voltage. The internal reference voltage is disconnected. The external reference voltage, which may vary from +1 volt to +10 volts DC, is connected to the resistance ladder through the reference amplifiers. The null is achieved in the same manner as described in DC measurement mode. The decimal point position, however, indicates the arithmetical value of the ratio.

## AC AND MV/OHMS CONVERTERS

The AC Converter converts the AC input signal to a DC voltage proportional to the rms value of the input signal sine wave.

The millivolt section of the MV/Ohms Converter amplifies a millivolt input signal by a factor of 100 or 1000. The ohms converter section supplies a precision current through an unknown resistance to develop a voltage proportional to the value of the resistance.

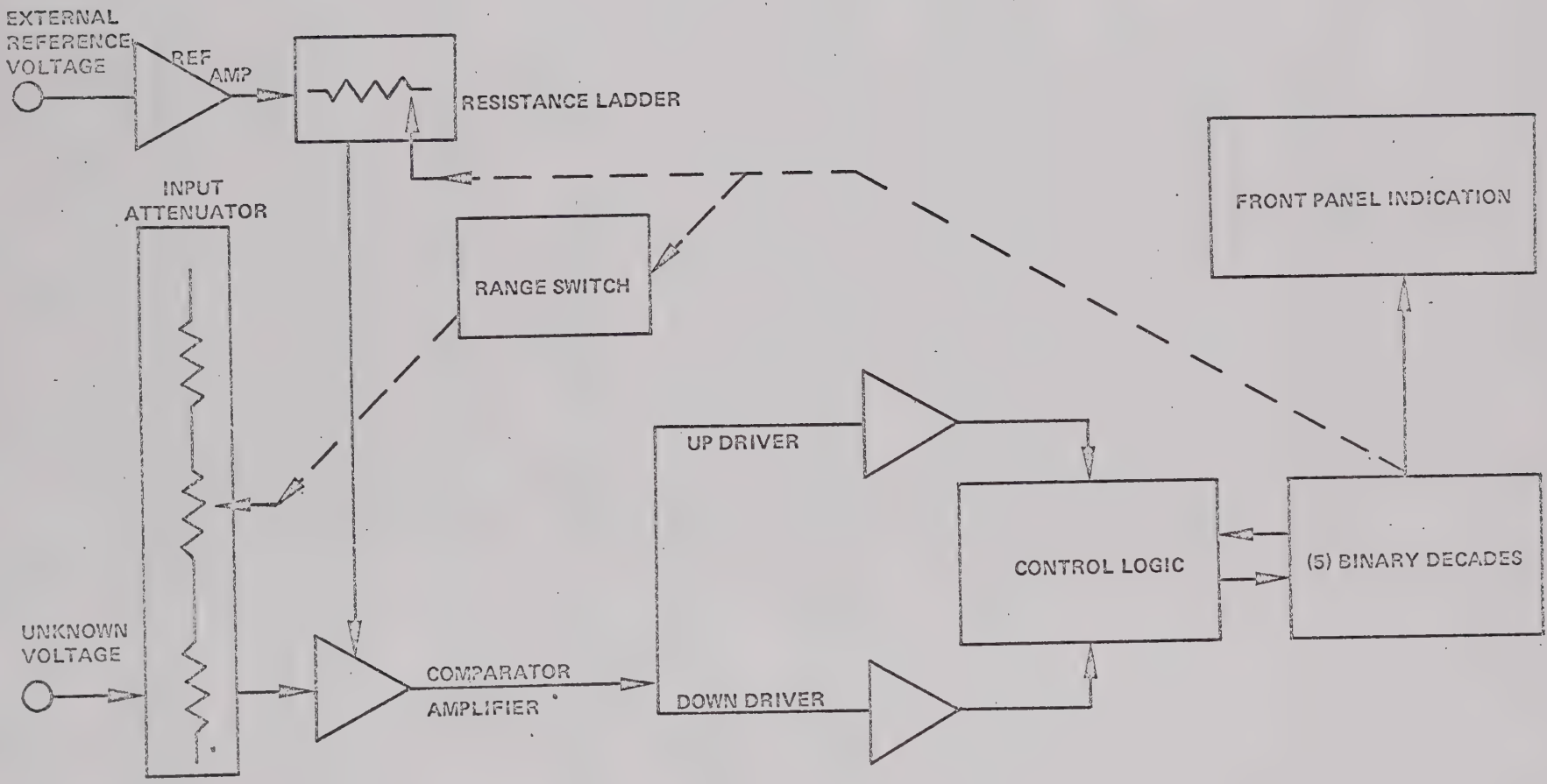



Figure 1. Simplified Block Diagram of Closed Loop Servo System.

The DC voltage output of the AC Converter is 1.09999 volts full scale and the MV/Ohms Converter 10.9999 volts full scale. The outputs are measured by the basic instrument and indicated on the front panel as AC, MV, or KΩ values.

## BLOCK DIAGRAM AND COUNTING LOGIC DESCRIPTION

In the following discussion it is assumed that all optional accessories are installed in the instrument.

Diagram 67-0002 is a block diagram of the instrument. The Power Supply, Print Output, and Input Buffer Assemblies, together with some of the logic and control paths, have been omitted in the interest of diagram simplicity. Units shown within dotted lines are mounted on the same assembly board. The five Decoders and the Polarity switch comprise the instrument resistance ladder and associated drive circuitry.

When the instrument is in DC or RATIO measurement mode, the input signal is applied to the Input Selector Assembly and routed directly to the Input Attenuator. In RATIO measurement mode, an external +1 to +10 reference voltage is applied to the Input Selector Assembly. The reference voltage is routed to the Reference Amplifiers.

In the AC measurement mode, the AC input signal is routed through the Input Selector Assembly to the AC Converter Assembly. There it is converted to 1.09999 volts DC full scale.

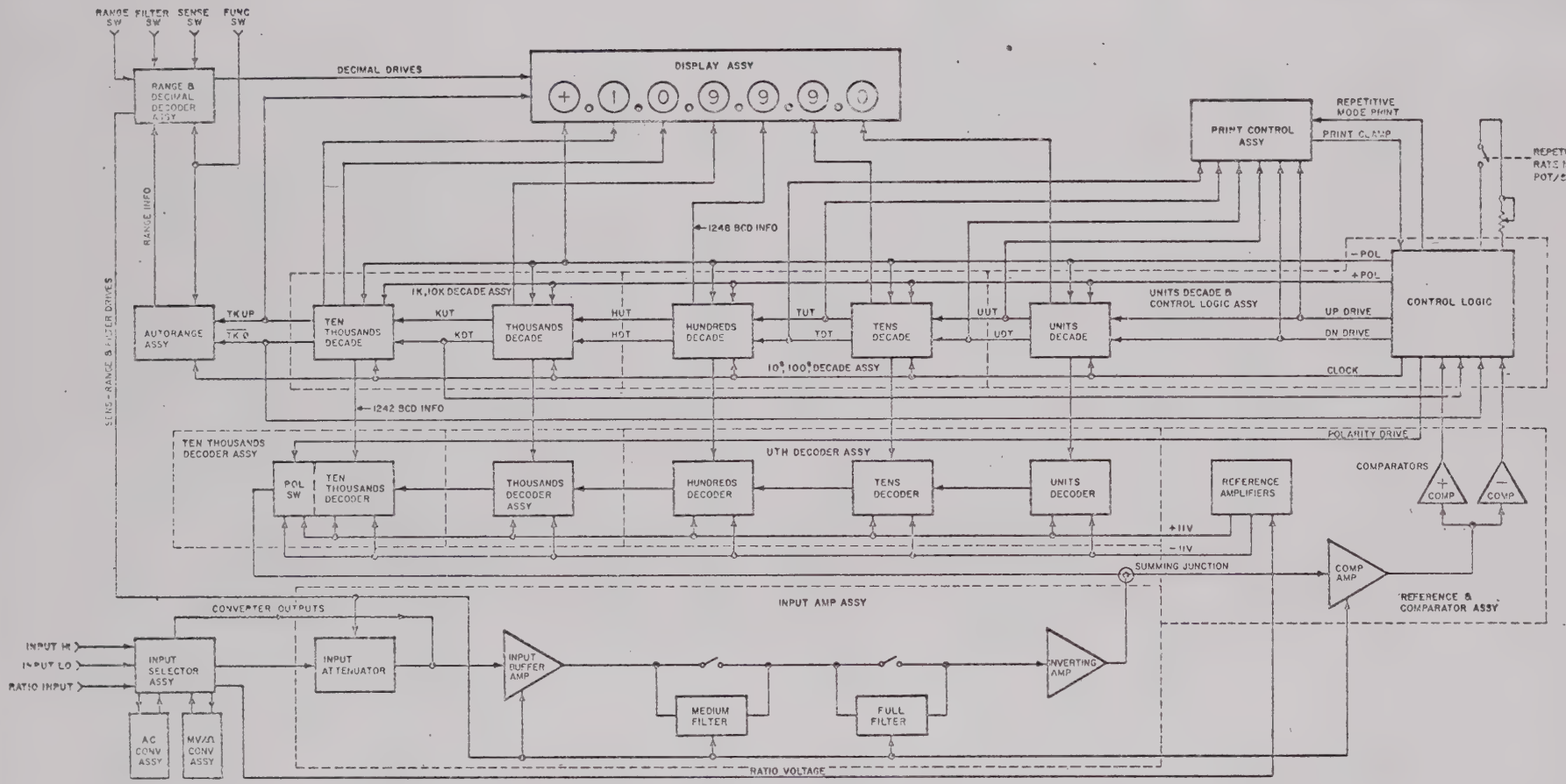
In the MV or KΩ measurement mode, the input signal is routed through the Input Selector Assembly to the MV/Ohms Converter Assembly. There it is converted to 10.9999 volts DC full scale.

The outputs of the AC and MV/Ohms Converters are routed through the Input Selector directly to the Input Buffer Amplifier, bypassing the Input Attenuator.

In the DC or RATIO measurement mode, when the input signal amplitude is between 11 and 109.999 volts the signal is attenuated by a factor of 10 to 1 by the Input Attenuator. When the input signal amplitude is between 110.00 and 1099.99 it is attenuated by a factor of 100 to 1. The degree of attenuation is controlled by signals from the Range and Decimal Decoder Assembly.

The Input Buffer Amplifier is a high gain, field effect transistor input, operational amplifier. It is connected potentiometrically for maximum input impedance. In the 1-volt range, the gain is 10 and in the 10, 100, 1K and 10K ranges, the gain is 1. The gain is controlled by signals from the Range and Decimal Decoder Assembly.

When the instrument front panel FILTER OFF switch is depressed, the output of the Input Buffer Amplifier is applied to the Inverting Amplifier input with no filtering.




BLOCK DIAGRAM
MODEL 6753

D 15318 67-0002

67-0002

Both the Medium Filter and Full Filter are a combination of passive and active filters. When the FILTER MED switch is depressed, the Medium Filter is activated. When the FILTER FULL switch is depressed, both the Medium and Full Filters are activated. The Filters are controlled by signals from the Range and Decimal Decoder Assembly.

The Inverting Amplifier is a unity gain operational amplifier that isolates the Input Buffer Amplifier and Filters from the Summing Junction.

The output currents of the Input Amplifier Assembly and the Resistance Ladder are summed at the Summing Junction and applied to the Comparator Amplifier.

The Comparator Amplifier has an output of zero volts when the instrument is in a null condition. If the Summing Junction output changes the current equivalent of 100 microvolts in a positive direction, the Comparator Amplifier output changes 0.3 volts in a positive direction. Conversely, when the Summing Junction output swings negative the Comparator Amplifier output goes negative. The output of the Comparator Amplifier is applied to the Positive and Negative Comparators.

The Positive Comparator input is biased at +0.3 volt. When the input is less positive than +0.3 volt, the Positive Comparator output is -0.3 volt. When the input becomes greater than +0.3 volt, the Comparator output changes to +3 volts.

Operation of the Negative Comparator is similar to the Positive Comparator, except the input is biased at -0.3 volt. When the input is less negative than -0.3 volt, the output is -0.3 volt. When the input becomes greater than -0.3 volt, the output changes to +3 volts.

The outputs of the Comparators are applied to the Control Logic.

The Control Logic performs the following functions:

1. Generates clock pulses that synchronize Decade and Autorange operations.

2. Utilizes the pulses received from the Positive and Negative Comparators to develop Up Drive and Down (DN) Drive pulses and applies the pulses to the Units Decade and the Print Control Assembly.

3. Controls:

   a. The instrument front panel polarity indication.

   b. Polarity of output signals from the Decades to the Decoders.

   c. Operation of the Polarity Switch.

4. Enables control of the signal tracking repetitive mode of operation.

The clock output is a 25 μSec pulse generated at a 4 kilohertz rate. The output is applied to the Decades and Autorange Assembly to synchronize circuit operation with receipt of Up and Down Drive pulses and up and down range pulses, respectively.

When the Polarity Switch is in the positive polarity configuration and the Positive Comparator fires, the Control Logic generates an Up Drive pulse to the Units Decade and the Print Control Assembly. If the Negative Comparator had fired instead, the Control Logic would have generated a Down Drive pulse. When the Polarity Switch is in the negative polarity configuration and the Positive Comparator fires, a Down Drive pulse is generated. In the negative polarity configuration, if the Negative Comparator had fired an Up Drive pulse would have been generated.

The Control Logic changes the instrument polarity configuration when the front panel numerical readout is all zeros and a Down Drive pulse is generated.

The instrument can be changed from constant tracking to repetitive tracking when the front panel REPETITIVE MODE switch/potentiometer is positioned to ON. The switch/potentiometer also enables control of the repetitive mode tracking rate. In the repetitive mode, the Control Logic tracks the input signal for 60 milliseconds and then:

1. Locks out signals from the Positive and Negative Comparator until another repetitive-mode-start pulse is generated.

2. Applies a Repetitive-Mode-Print pulse to the Print Control Assembly that forces a printout if the front panel PRINT AUTO switch is depressed.

The Decades generate 1-2-4-8 BCD positive polarity information to the Display Driver and Print Output Assemblies (not shown) and 1-2-4-2* BCD information to the Decoders. The latter information may be either positive or negative, dependent on the instrument polarity configuration.

The Decades use tri-quinary logic to minimize tracking time. When receiving Up Drive pulses, the Decades, except the Ten Thousands Decade, count up 1-3-5-7-9-up transfer. The Ten Thousands Decade counts 1-3-5-7-9-10-up range. When receiving Down Drive pulses, the Decades, except the Ten Thousands Decade, count down from an odd-numbered state to the next lower even-numbered state, then directly to zero and then, on the next Down Drive pulse, down transfer. When the Ten Thousands Decade is in a 10-state, it counts down 9-8-1-0-down range. When in any state other than 10, it counts down from an odd-numbered state to the next even-numbered state and then to 1. The next two Down Drive pulses cause it to count to zero and then to down range.

To illustrate the counting logic; assume that the input signal increases from zero to 0.0190 volts and then decreases to zero (table 1). A series of Up Drive pulses cause the Units

Table 1. Typical Logic Counting Sequence.

| DRIVE PULSE | DECADE STATES | | | | |
|---|---|---|---|---|---|
| | 10K | 1K | 100 | 10 | 1 |
| | 0 | 0 | 0 | 0 | 0 |
| UP | 0 | 0 | 0 | 0 | 1 |
| UP | 0 | 0 | 0 | 0 | 3 |
| UP | 0 | 0 | 0 | 0 | 5 |
| UP | 0 | 0 | 0 | 0 | 7 |
| UP | 0 | 0 | 0 | 0 | 9 |
| UP (UUT) | 0 | 0 | 0 | 1 | 9 |
| UP (UUT) | 0 | 0 | 0 | 3 | 9 |
| UP (UUT) | 0 | 0 | 0 | 5 | 9 |
| UP (UUT) | 0 | 0 | 0 | 7 | 9 |
| UP (UUT) | 0 | 0 | 0 | 9 | 9 |
| UP (TUT) | 0 | 0 | 1 | 9 | 9 |
| DN | 0 | 0 | 1 | 9 | 8 |
| DN | 0 | 0 | 1 | 9 | 0 |
| DN (UDT) | 0 | 0 | 1 | 8 | 0 |
| DN (UDT) | 0 | 0 | 1 | 0 | 0 |
| DN (TDT) | 0 | 0 | 0 | 0 | 0 |

Decade to count 1-3-5-7-9. On the next Up Drive pulse, the Units Decade generates a Units Up Transfer (UUT) pulse. The Units Decade remains in a 9 state. The UUT pulse and succeeding UUT pulses cause the Tens Decade to count 1-3-5-7-9 and then generate a Tens Up Transfer (TUT) pulse. The Tens Decade remains in a 9 state. The TUT pulse causes the Hundreds Decade to count to 1. The front panel numeral indication is now 0.0199, which is higher than the value of the input signal. The instrument logic then generates two Down Drive pulses. The first pulse causes the Units Decade to count to 8, and the second pulse to count to zero. The front panel indication is now 0.0190, which is correct. When the input signal decreases to zero, a series of Down Drive pulses are generated. The Units Decade is already at zero, so the first Down Drive pulse causes the Decade to generate a Units Down

Transfer (UDT) pulse. The UDT pulse sets the Ten Decade to 8. The next Down Drive pulse and resultant UDT pulse cause the Tens Decade to count to zero. The third Down Drive and UUT pulses cause the Tens Decade to generate a Tens Down Transfer (TDT) pulse which in turn sets the Hundreds Decade to zero. The front panel indication is now 0.0000.

Assume that the input signal is 10.9999 volts. When all the Decades have counted up to 9, the next Up Drive pulse sets the Ten Thousands Decade to 10. The other Decades remain in the 9 state. The front panel indication is 10.9999. The instrument is now in overrange. A numeral 1 appears in the overrange window of the front panel indication whenever the Ten Thousands Decade is in the 10 state.

Assume that the instrument is in AUTO RANGE and that the input signal voltage increases from 10.9999 to 11.000 volts. An Up Drive pulse causes the Ten Thousands Decade to generate a Ten Thousands Up (TKUP) pulse that causes the Autorange Assembly to shift to the next higher range. The instrument logic then generates a series of:

1. Down drive pulses that sets the Ten Thousands Decade to 1 and the other Decades to zero.

2. Up drive pulses that set the Units, Tens, and Hundreds Decades to 9 and the Thousands Decade to 1.

3. Down Drive pulses that set the Units, Tens, and Hundreds Decades to zero. The front panel indication is now 11.000.

If the instrument was in the 10-volt manual range instead of AUTO RANGE when the input signal increased from 10.9999 to 11.000 volts, the front panel indication would remain 10.9999. The TKUP pulse from the Ten Thousands Decade would be applied to the Display Driver and cause the overrange 1 to slowly and continuously blink, indicating the reading is in error.

If the input signal decreases from 11.000 to 9.9999 volts, the instrument logic generates a series of Down Drive pulses that successively set all the Decades to zero. The Ten Thousands Decade is now in a Not Ten Thousands Zero ($\overline{TK0}$) state that causes the Autorange Assembly to shift to the next lower range on the next clock pulse. At this point, a polarity change is prevented by the Control Logic. The logic then generates Up Drive pulses until all the Decades are in a 9 state.

If the input signal changes from a positive to a negative polarity, the logic generates Down Drive Pulses that set all the Decades to zero. The next Down Drive pulse causes the Thousands Decade to generate a Thousands Down Transfer (KDT) pulse and the Ten Thousands Decade to generate a $\overline{TK0}$ state. The two pulses are applied to the Control Logic and indicate that all Decades are in a zero state. The Control Logic reverses the – and + polarity outputs and the instrument is in a negative polarity configuration.

The Decade counting sequence is so rapid that when watching the front panel indication the change appears to be nearly instantaneous.

The Reference Amplifiers section of the Comparator and Reference Assembly contains a voltage reference module that supplies 10 volts. The voltage is amplified by a factor of 1.1. There are two amplifiers. When the instrument is in any measurement mode other than RATIO, the Reference Amplifiers furnish the internally generated 10 volts as a +11 and -11 reference voltage to the Decoder Assemblies and Polarity Switch. In the RATIO mode the voltage reference module is disconnected from the amplifier and an external DC reference voltage is substituted. The external voltage amplitude can be from +1 to +10 volts.

Figure 2 is a simplified presentation showing the operating principles of the Decoders.

When the instrument is in the positive polarity configuration, the numbered switches are connected to the -11 reference voltage and the POLARITY switch to the +11 reference voltage. The numbered switches tend to drive the Summing Junction negative. The POLARITY switch resistor of 36.36 kilohms equals the parallel combination of the four numbered switch resistors and the 400 kilohm resistor. The +11 volts applied to the POLARITY switch resistor offsets the -11 volts applied through the numbered switch resistors and the Summing Junction is held at zero. If the associated Decade driving the Decoder sets a 1, the 400 kilohm resistor will be switched to +11 volts and the Summing Junction output will move positive the current equivalent of 1 volt. When the Control Logic causes the instrument polarity configuration to change, the POLARITY switch in figure 2 is driven to the -11 volts. At the same time the - and + polarity outputs of the Control Logic are reversed. This condition causes the associated Decade to drive the numbered switches to the +11 voltage. Again the output of the Decoder is zero. When a 1 is now set, the 400 kilohm resistor is switched to -11 volts and the Summing Junction is driven negative.

The Autorange Assembly is a 5-stage Counter. When the front panel RANGE AUTO switch is depressed, the Assembly sets to the 10-volt range. It will then shift to the next higher or lower range on command from the Ten Thousands Decade. It is shifted up when the input signal exceeds 109999 and down when the input signal decreases below 10000. When the front panel FUNCTION MV-DC switch is depressed the Autorange Assembly, in conjunction with the Ten Thousands Decade, controls the ranging between the MV and DC measurement modes. The output of the Autorange Assembly is applied to the Range and Decimal Decoder Assembly.

The Range and Decimal Decoder Assembly decodes range information from either the Autorange Assembly or the front panel manual RANGE switches and function information from the FUNCTION switches. The information enables the Assembly to:

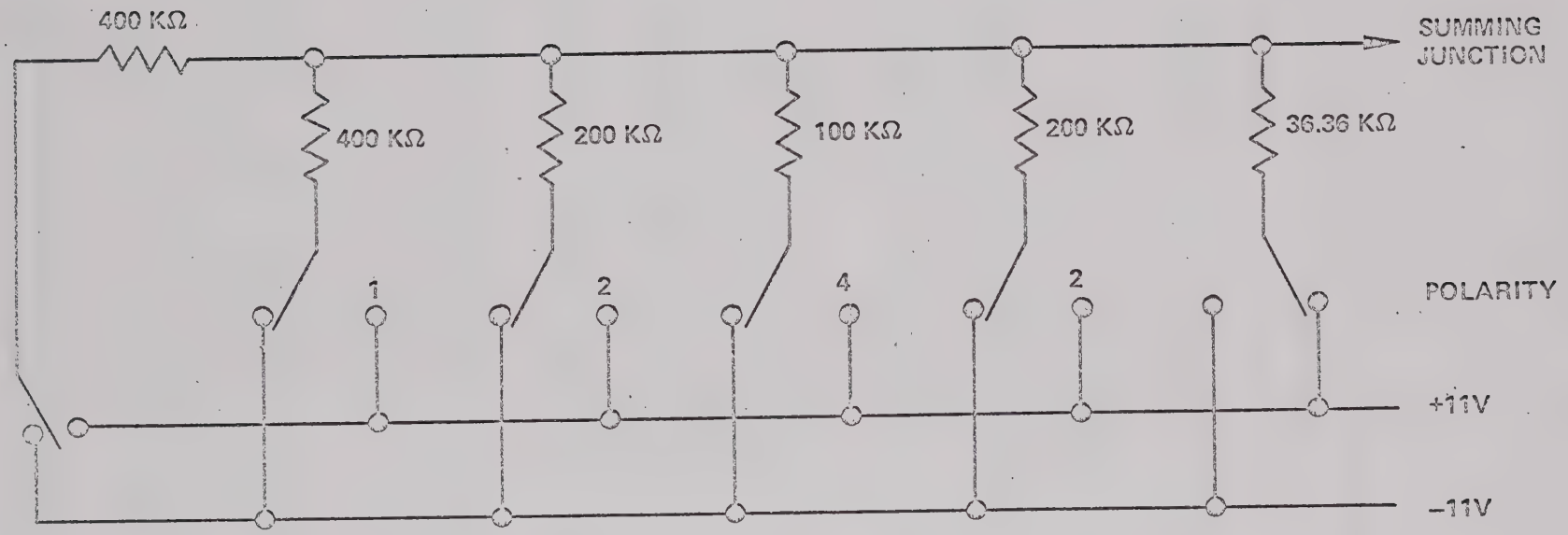



Figure 2. Simplified Decoder.

1. Illuminate the appropriate decimal indicator on the Display Assembly.
2. Control attenuation relays on the Input Attenuator.
3. Control the gain of the Input Buffer Amplifier.

Dependent upon the positions of the front panel FILTER and SENSITIVITY switches, the Assembly also selects the degree of input signal filtering and instrument sensitivity.

The Display Assembly receives 1-2-4-8 BCD information from the Decades. Each Decade supplies information to an associated numeral readout tube, i.e., Units Decade to units readout tube and Tens Decade to tens readout tube. The Ten Thousands Decade supplies both the ten thousands and the overrange readout tubes. The BCD information is decoded to 10-line decimal code and used to illuminate the numeral readout tubes. Decimal information received from the Range and Decimal Decoder Assembly illuminates the appropriate decimal indicator. The polarity indicators are illuminated by the – and + polarity outputs of the Control Logic.

When the instrument is in the AUTO PRINT mode, with the REPETITIVE mode switch off and with no signal input filtering, the Print Control Assembly issues a print command to the Print Output Assemblies when no Up Drive or Down Drive pulses are received from the Control Logic for 15 milliseconds--a null condition. Another print command will not be issued until the value of the input signal changes and another null is attained. From the time the Print Control detects a null and issues a print command until the time a Reset signal is generated, the Print Control applies a Print Clamp command to the Control Logic. The Print Clamp command locks out further up and down pulses from the Positive and Negative Comparators to the Control Logic.

If the voltage being measured has an AC component and the Print Control Assembly cannot detect a null at the input of the Units Decade within 75 milliseconds, the Assembly will:

1. Desensitize itself and scan the Tens Decade for a null.
2. After 75 milliseconds of scanning the Tens Decade without detecting a null, further desensitize itself and scan the Hundred Decade input.
3. If, in an extreme condition, a null still cannot be detected after scanning the Hundreds Decade for 75 milliseconds, issue a Print command to the Print Output Assemblies.

When a printout is made, the printout information indicates the fact that desensitization has or has not occurred. If desensitization has occurred, the degree is indicated.

In the repetitive tracking mode, the Print Control Assembly issues a Print Command each time it is so directed by the Control Logic.

There is a power supply (not shown in the block diagram) mounted on the Print Control Assembly but outside of the guard shield. The power supply furnishes voltage to voltage-state print output assemblies, to the relay coils of remote buffer assemblies, and to the buffered print output assemblies as reference voltage.

## INSTRUMENT SENSITIVITY

Instrument sensitivity can be defined as the minimum input signal that will cause a one-digit change in the units window of the front panel numerical indication.

The sensitivity of the Model 6753 is determined by the gain of the Comparator Amplifier section of the Comparator Amplifier and Reference Assembly. Figure 3 is a simplified schematic diagram of the Comparator Amplifier. Switches X2, 4, and 16 control the amplifier gain.

The nominal gain of COMP AMP 1 is 30 and COMP AMP 2, 100. The overall gain is 3000. With switches X2, 4, and 16 open, a 100-microvolt input signal will result in a 0.3-volt output signal. A nominal value of 0.3 volt is required to drive the positive and negative comparators which in turn drive the control logic. The instrument therefore has a sensitivity of 100 microvolts.

When switch X2 is closed the COMP AMP 1 feedback is doubled and the gain of COMP AMP 1 is reduced to 15. It would then require an input signal of 200 microvolts to maintain the 0.3 volt output of COMP AMP 2. The instrument sensitivity is now 200 microvolts.

When switch X2 is open and switch 4 is closed, the gain of COMP AMP 2 is reduced to 25 and the overall gain to 750. An input signal of 400 microvolts is now required to produce a 0.3-volt output. If, while switch 4 was closed, switch X2 was also closed the maximum sensitivity would be 800 microvolts.

Switches X2, 4, and 16 are front panel mounted SENSITIVITY switches. Switches 4 and 16 are interlocked and cannot be closed simultaneously. Therefore instrument sensitivity cannot be reduced below 3200 microvolts by means of the switches.

## FILTER RESPONSE

Figure 4 shows the instrument filter response with medium and full filtering. At 60 hertz the Medium Filter rejection is 40 decibels and the Maximum Filter rejection is 100 decibels. At 400 hertz the Medium Filter rejection is 92 decibels and the Maximum Filter, by extrapolation, greater than 100 decibels.

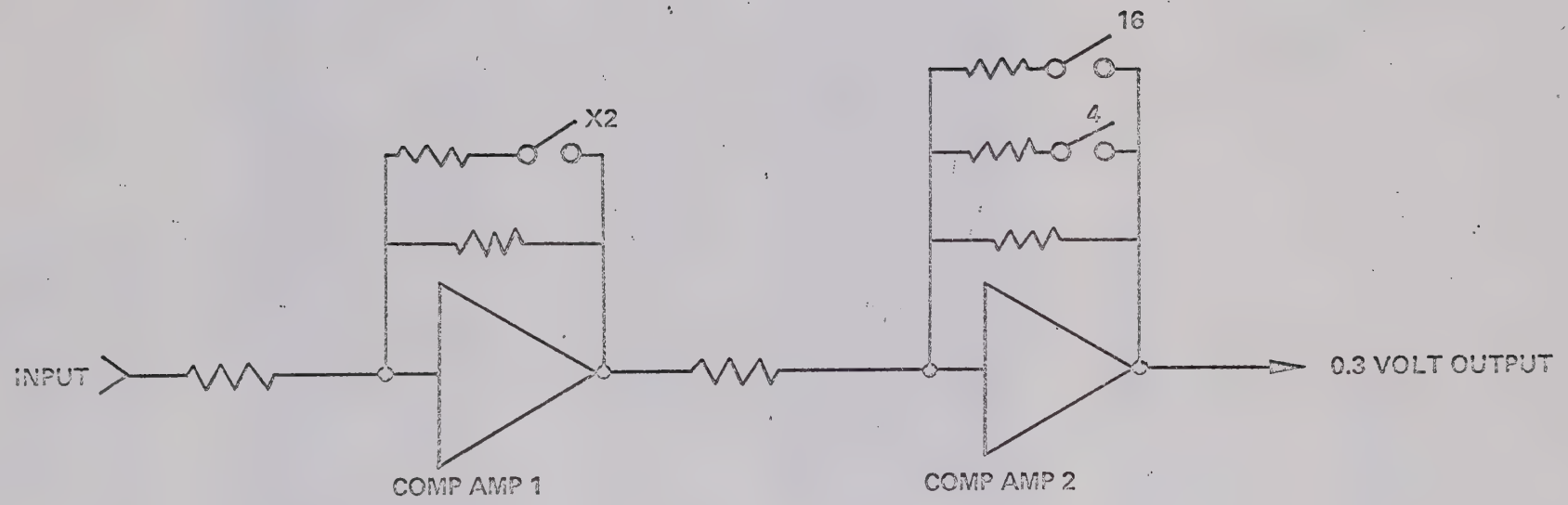



Figure 3. Comparator Amplifier Simplified Schematic Diagram.

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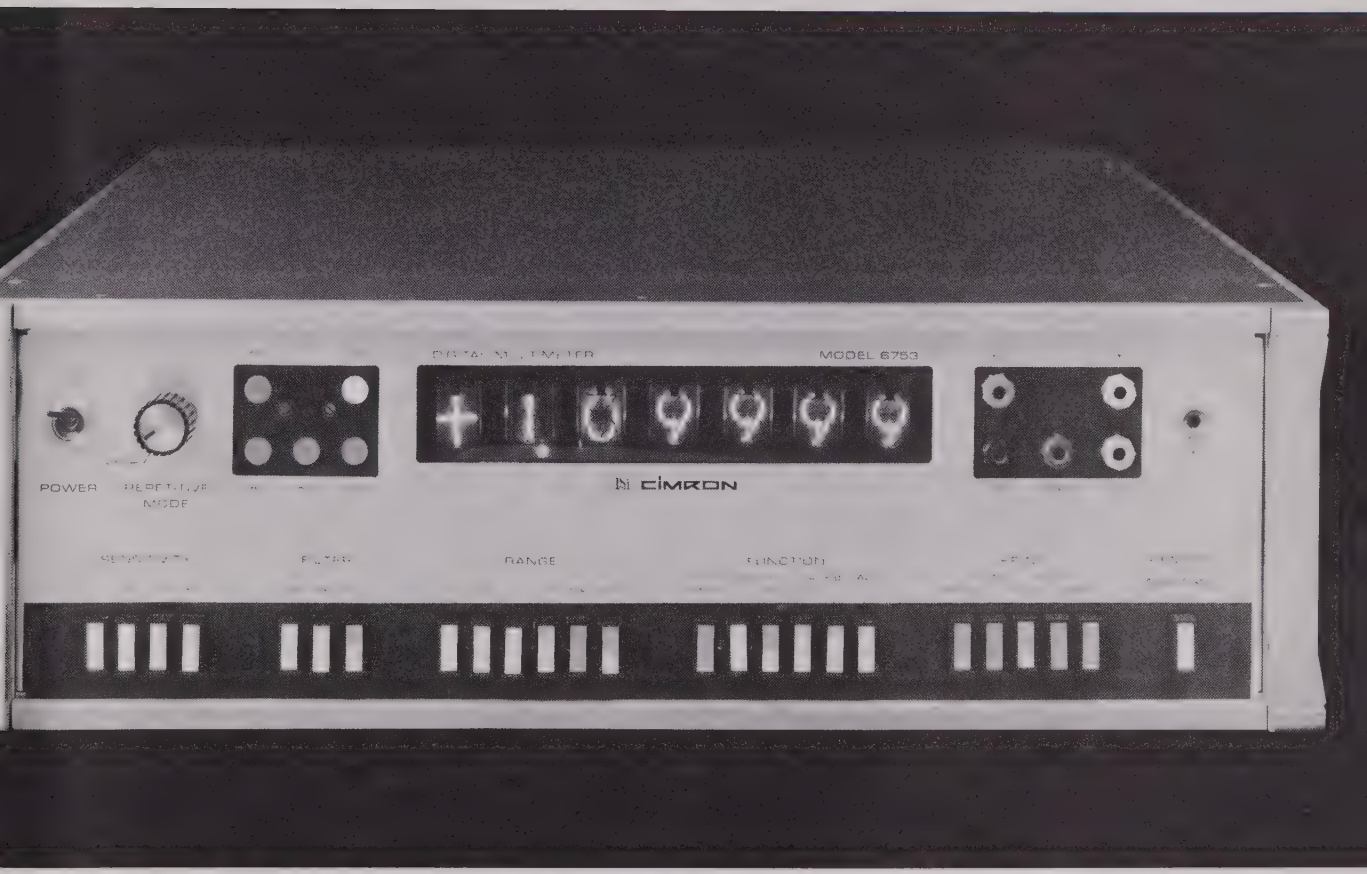
# MODEL 6753
# DIGITAL MULTIMETER




**FEATURES:**

- AC/DC AND DC RATIO, FOUR RANGES
- OHMS, FIVE RANGES
- FULLY REMOTELY PROGRAMMABLE
- AUTORANGING, ALL FUNCTIONS
- REPETITIVE MODE
- FIVE PRINT OPTIONS
- OUT-OF-RANGE INDICATION
- AUTOMATIC DESENSITIZATION
- 0.001% ACCURACY
- ALL IC CIRCUITRY

## DESCRIPTION

Cimron "Fastrack" Model 6753 Digital Multimeter is a six digit, all IC tracking logic volt-ratio meter with AC, DC, millivolt and ohms function plug-in options. Feature for feature, the 6753 has no equal in its price range either for systems applications or for bench use. The basic instrument measures DC and DC ratios with an accuracy of ±(0.001% full scale + 0.005% of reading). The most significant digit, numeral 1, provides 10% overranging and indicates when the meter is out of range by blinking. The instrument is capable of 14 measurements per second and is fully programmable.

The Model 5775 AC Converter ranges from 10 microvolts to 1099.99 volts AC with an accuracy of ±(0.02% full scale + 0.08% or reading). The millivolt range option extends the 6753's capability to 100 nanovolts DC and the ohms option measures from 10 milliohms to 10 megohms. Millivolts and ohms options are combined as one plug-in as a cost saving feature.

Autoranging from millivolts to DC and for all other functions tracks from the lower to upper limits without touching a button.

The Remote Control option permits remote selection of all controls on the front panel including function, range, decimal, sensitivity, filter, print, energizing of external reference, energizing auto desensitizing, and trigger rate when the meter is in repetitive mode. When in remote control front panel controls are locked out, thus preventing the loss of data due to inadvertent operation of a front panel control.

A manual or automatic "Repetitive Mode" control, standard in the 6753, permits a selectable print-on-command without having to wait for a null. Printout is at selected gated rate from 1 to 5 readings per second or when in remote mode, from 1 to 10 readings per second.

Five printout options are available which include 10-line contact closure, 1-2-4-8 BCD Contact Closure, 1-2-4-8 BCD Voltage State (0 to +12), 1-2-4-8 BCD Voltage State (0 to −12), and 1-2-4-8 BCD DTL logic levels.

All options are circuit modules which are simple to install plug-ins and are located within the chassis. No external accessories are required.

The 6753's advanced design is unexcelled. From its box-within-a-box construction which provides for maximum isolation, to its exclusive retractable handles this Cimron multimeter exemplifies **Customer Concern**. Easy to read nixie® tubes, pushbutton controls for eliminating intermediate switching, illuminated function indicators, and numerous other convenient features denoting quality are incorporated in the 6753.

## AUTOMATIC DESENSITIZATION

A special Automatic Desensitization circuit in the 6753 assures a valid reading in the presence of extreme noise. When this condition exists the desensitization circuit is automatically activated after a 75 ms trial period and the least significant decade is ignored. If the extreme condition remains 75 ms longer, the next decade in sequence is ignored until the third least significant decade is reached, 75 ms later. At this time a readout with accompanying print signal will be given. The recorded data will show this as desensitized data and the number of decades ignored will be identified.

Conventional DVMs either record data continuously without regard to its validity, or in the presence of noise, are unable to balance and hence record no data.

## TRACKING LOGIC

The 6753 Multimeter employs advanced tracking logic and the 4 KHz sample rate of a solid state comparator amplifier which enables the 6753 to conduct high-speed measurements, maintaining the ability to respond to sudden changes of the input signal. See block diagram Figure 1.

Average response time for the basic meter is 50 milliseconds, with worst case of 75 milliseconds for a full step change. It can measure Signal A (shown in Figure 2) within 75 milliseconds and issue a print command of the steady state value. Further print commands will not be issued unless the input changes, and encoding time will be far less than 75 ms for small input changes. Since fixed encoding time DVMs are usually set to read at the rate of 5 samples per second or less, the printout command will be given at 200 milliseconds intervals even though the input may not be changing between encodings.

As the system scans to the next channel and encounters Signal B, which has a rise time to steady state in excess of 75 milliseconds, logics designed to issue a print command at the end of 200 milliseconds will cause an erroneous 8 VDC to be recorded. Cimron's Fastrack 6753 logic will follow Signal B, changing as it changes, and issue a print command for only the true steady state value when it is attained, unless otherwise commanded by optionally programming the "Repetitive Mode".

®BURROUGHS TRADEMARK

CIMRON

# SPECIFICATIONS
# MODEL 6753
# DIGITAL MULTIMETER

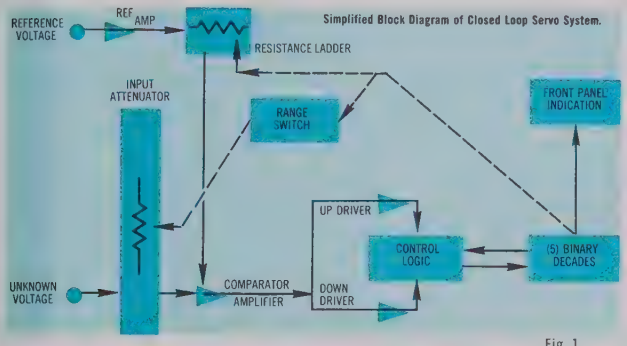



Fig. 1

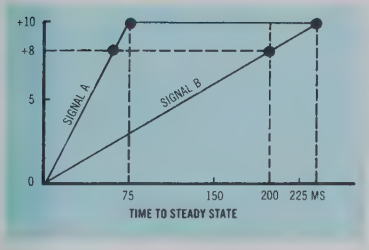



Fig. 2

## SPECIFICATIONS – DC

**Voltage Ranges:** ±1.09999, ±10.9999, ±109.999, and ±1099.99V. Manual, or automatic optional

**Accuracy:** 10, 100, 1000 VDC Ranges –

SHORT TERM (30 days); ±(0.001% F.S. +0.005% RDG.) at 25°C ±5°C

LONG TERM (6 months); ±(0.002% F.S. +0.01% RDG.) at 25°C ±5°C

1 volt range –

LONG TERM (6 months); ±(0.01% F.S. +0.005% RDG.) at 25°C ±5°C

**Input Resistance:** (on or off null)

1V Range; 1000 megohms minimum

10V Range; 10,000 megohms minimum

100V Range; 10 megohms minimum

1000V Range; 10 megohms minimum

**Temp. Coefficient:** ±(0.0002% F.S. +0.0001% RDG.)/°c

**Common Mode Rejection:** With 100 Ohms unbalance in either input lead – DC: 10,000,000:1 (140dB);

AC (60 Hz): 1,000,000:1 (120dB)

Input may be floated 1000 VDC or peak AC

**Out of Range Indication:** Overrange numeral "1" blinks when F.S. is exceeded in Manual mode

**Normal Mode Rejection:**

Filter Out; 0 dB

Filter Med; 40 dB at 60 Hz
80 dB at 400 Hz

Filter Max; 90 dB at 60 Hz
increasing 36 dB/octave

**Settling Time:** Single range incl. polarity change to 0.002% F.S.

Filter Out; 75 ms (IV Range; 300 ms)

Filter Med; 300 ms

Filter Max; 700 ms

(add 25 ms per range change – filter out)

## DC/DC RATIOS

**Ratio Ranges:** .109999:1, 1.09999:1, 10.9999:1, 100.999:1, (Autoranging optional)

**Accuracy:** $\pm(0.001\%\ \text{F.S.}\left(\frac{10}{\text{REF}}\right)+0.005\%\ \text{RDG})$

**Ext DC Ref. Input Resistance:** 10 megohms minimum

**Ext DC Ref. Voltage Range:** +1 to +10 VDC

## MODEL 5775 AC CONVERTER

**Conversion Method:** RMS equivalent of the average value of the input sine wave

**Settling Time:** To 0.1% of F.S.

Filter Out; < 100ms, 1 KHz up

Filter Med; < 300ms, 100 Hz up

Filter Max; < 700ms, 50 Hz up

**Voltage Ranges:** 1.09999, 10.9999, 109.999, & 1099.99VAC

**Frequency Range:** 50 Hz to 100 KHz

**Accuracy:** 50 Hz to 20 KHz 10uv to 750 VAC ±(0.02% F.S. +0.08% RDG)

20 KHz to 50 KHz 10uv to 500 VAC ±(0.05% F.S. +0.2% RDG)

50 KHz to 100 KHz 10uv to 250 VAC ±(0.1% F.S. +0.4% RDG)

**Input Impedance:** 1 Megohm constant, shunted by 100 picofarads

# SPECIFICATIONS
# MODEL 6753
# DIGITAL MULTIMETER

## MODEL 5789 MV/OHMS CONVERTER*
## MILLIVOLTS PREAMPLIFIER

| | |
|---|---|
| Two Full Scale Ranges: | 10.9999 & 109.999 MV DC |
| Accuracy: | 10 MV range; ±(0.01% F.S. +0.02% RDG.)<br>100 MV range; ±(0.01 F.S. +0.01% RDG.) |
| Gain Stability: | 0.01% for at least 30 days |
| Drift: | < 500 nanovolts per degree C after warm up |
| Input resistance: | 10 MV range; 10 megohms min<br>100 MV range; 100 megohms min |
| Settling Time: | 10 MV range; < 500 MS<br>100 MV range; < 100 MS<br>(to 0.01% F.S.) |
| Common Mode Rejection: | 10 MV range; 150 dB at DC, 140 dB at 60 Hz<br>100 MV range; 140 dB at DC, 130 dB at 60 Hz |

NOTE: All Solid State MOSFET input circuitry provides exceptional zero stability resulting in dependable readings when measuring very low level signals

**Millivolt and ohms options are combined on one plug-in board.*

## OHMS CONVERTER

| | |
|---|---|
| Five Full Scale Ranges: | 1.09999, 10.9999, 109.999, 1099.99 & 10999.9K ohms |
| Current Through Unknown Resistor: | 10 mA, 1 mA, 100 ua, 10 ua, & 1 ua respectively |
| Accuracy: | 1, 10, & 100 K OHM Ranges; ±0.005% F.S. or 0.01% RDG.<br>1000 K OHM Range; ±0.005% F.S. or 0.02% RDG<br>10,000 K OHM Range; ±0.02% F.S. or 0.05% RDG.<br>(Note: Above figures, whichever is greater) |
| Sensing: | 1, 10, 100 K OHM Ranges; 4 Wire.<br>1000 K & 10,000 K OHM Ranges; 2 Wire |
| Maximum Voltage Across Unknown Resistor: | 20 VDC (Out of range) |
| Settling Time: | 1, 10, & 100 K OHM Ranges; 100 MS<br>1000 K OHM Range; 250 MS<br>10,000 K OHM Range; 1 sec<br>(to 0.01% F.S.) |

## OPTIONAL ACCESSORIES

MV/OHMS Converter, AC Converter Remote Control, Print Outputs, Rear Input Connector, Rack Slides, Printer or Punch Interface Cable, H.V. Probe, Spare Parts Kit

## DIGITAL OUTPUT DATA

Display 5 digits plus 6th overrange 1-2-4-8 BCD. (11 columns of info) voltage state or contact closures. 10 Line Decimal, contact closures. DTL Logic ("O"=0V; "1"=+5V)

## REMOTE CONTROL

Non-Buffered

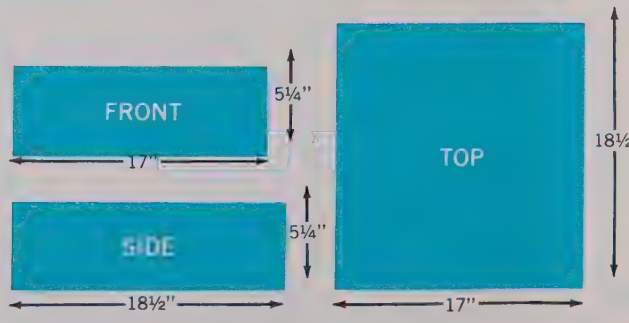
Buffered (Contact Closures) (+5V tap on Print Control Board supplies power)

## POWER & TEMPERATURE RANGE

105-125/210-250V: 60 Hz, (400 Hz optional)
10°C to +40°C (Storage −55°C to +85°C)

*Specifications subject to change without notice.*

| | |
|---|---|
| Dimensions: | Height 5¼" (13.34 Cm.)<br>Width 17" (43.18 Cm.)<br>Depth 18½" (46.99 Cm.) |
| Net Weight: | 45 lbs. |
| Shipping Weight: | 55 lbs. |

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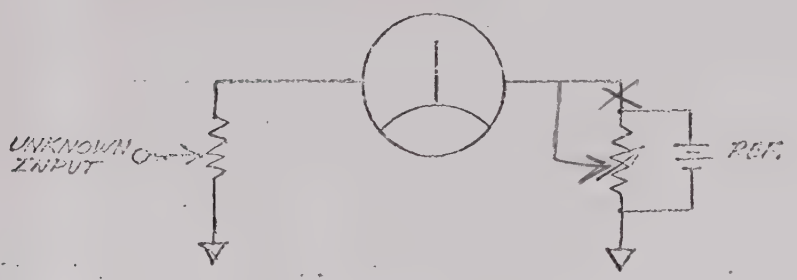
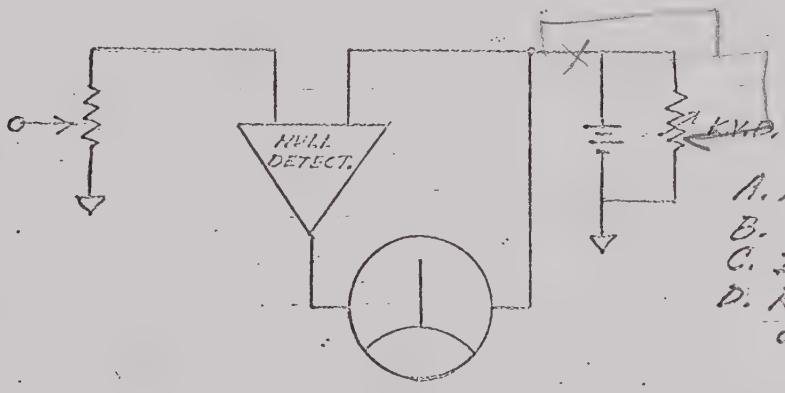
# GENERAL INFORMATION

## 1. SIMPLE GALVO COMPARATOR



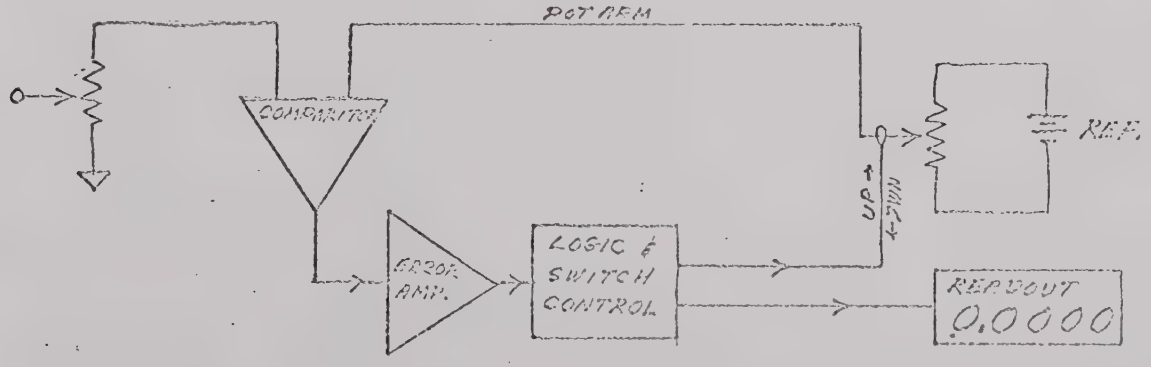

A. Accuracy dependent on ref. calibration
B. Sensitivity dependent on meter movement
C. Input Z infinite at NULL

## 2. DIFFERENTIAL VOLTMETER



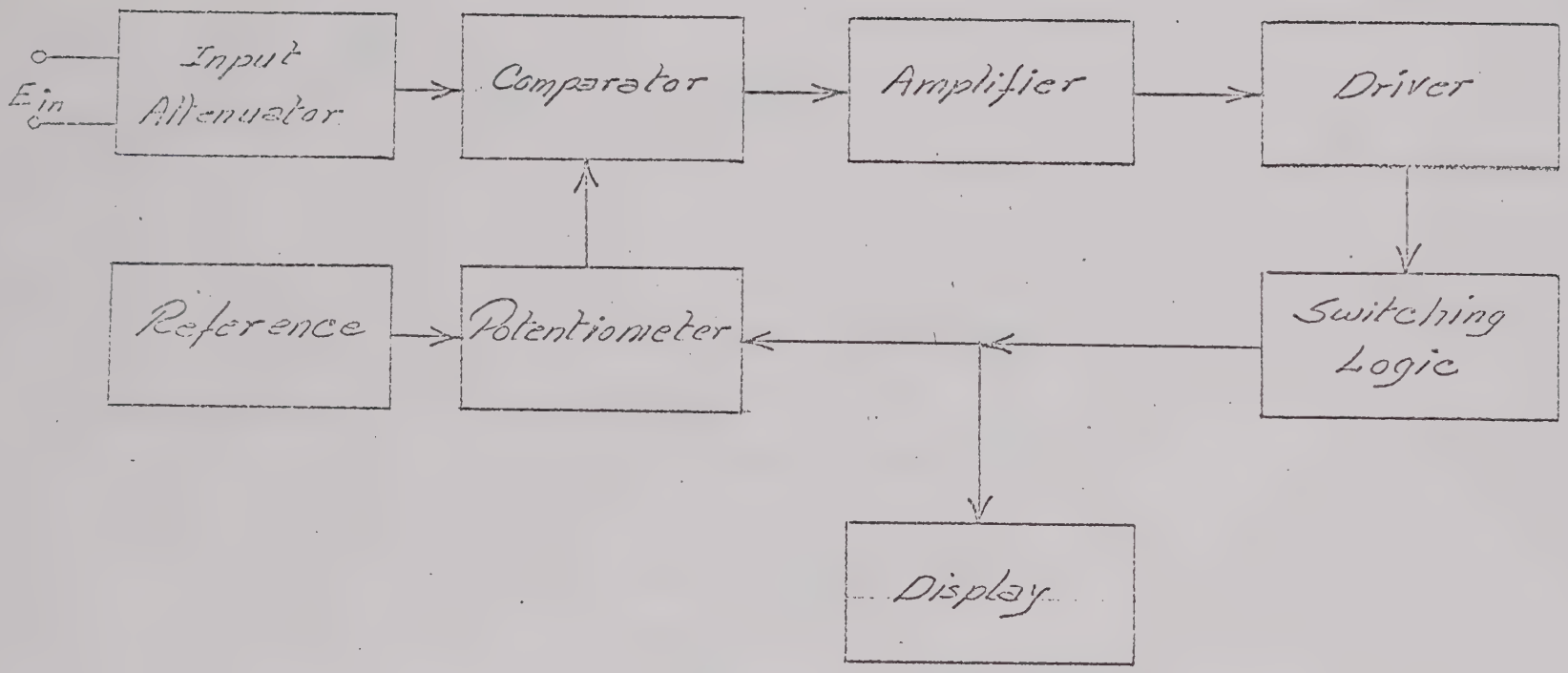

A. Accuracy better than .01%
B. Sensitivity as low as 100 μv
C. Input Z infinite at null
D. Response dependent on operator.

## 3. BASIC DIGITAL VOLTMETER



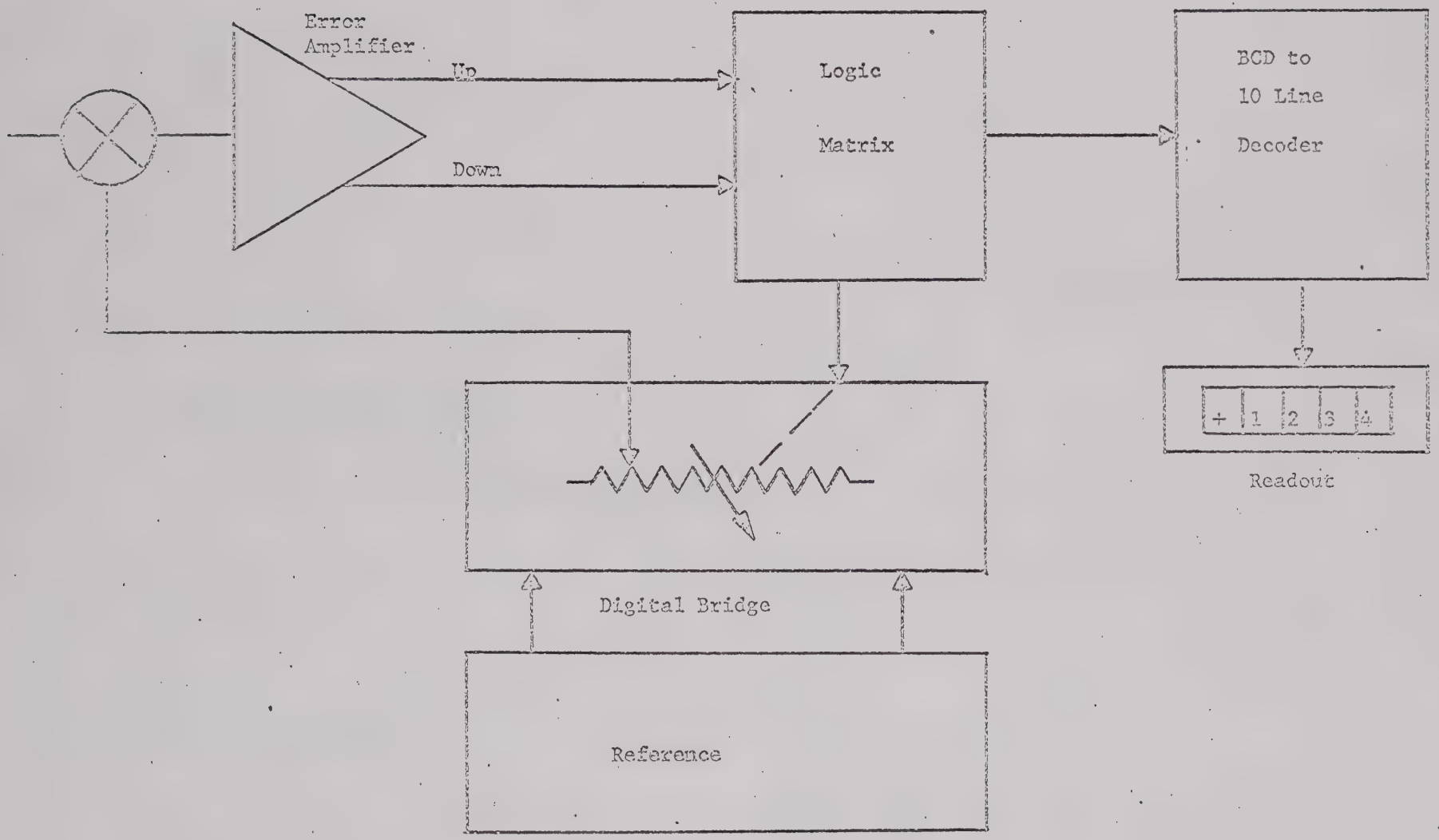

A. Accuracy better than .01%
B. Sensitivity as low as 100 μv
C. Input Z infinite at null
D. Response; 5 readings per sec

# Basic Digital Voltmeter.

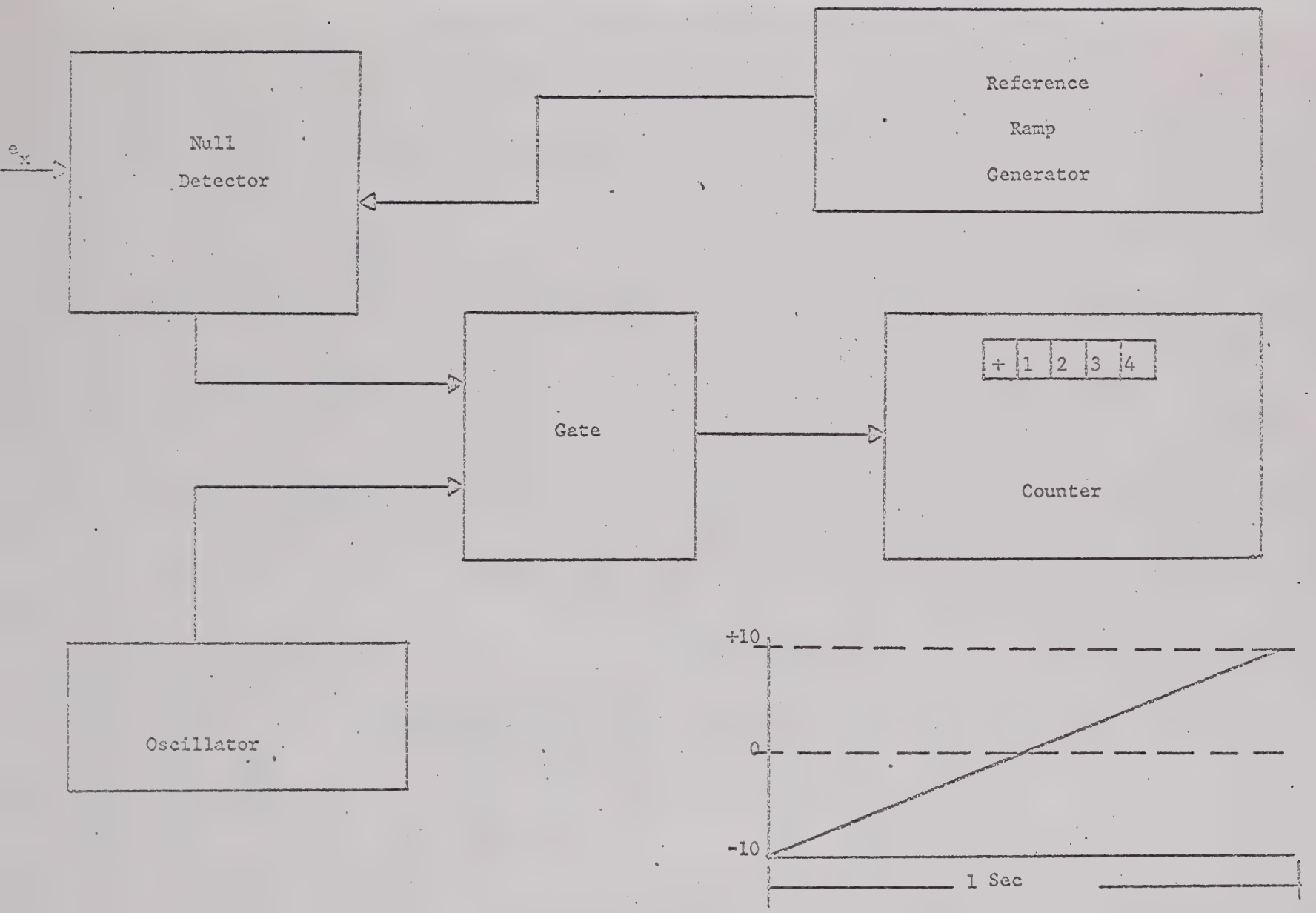



K.D.

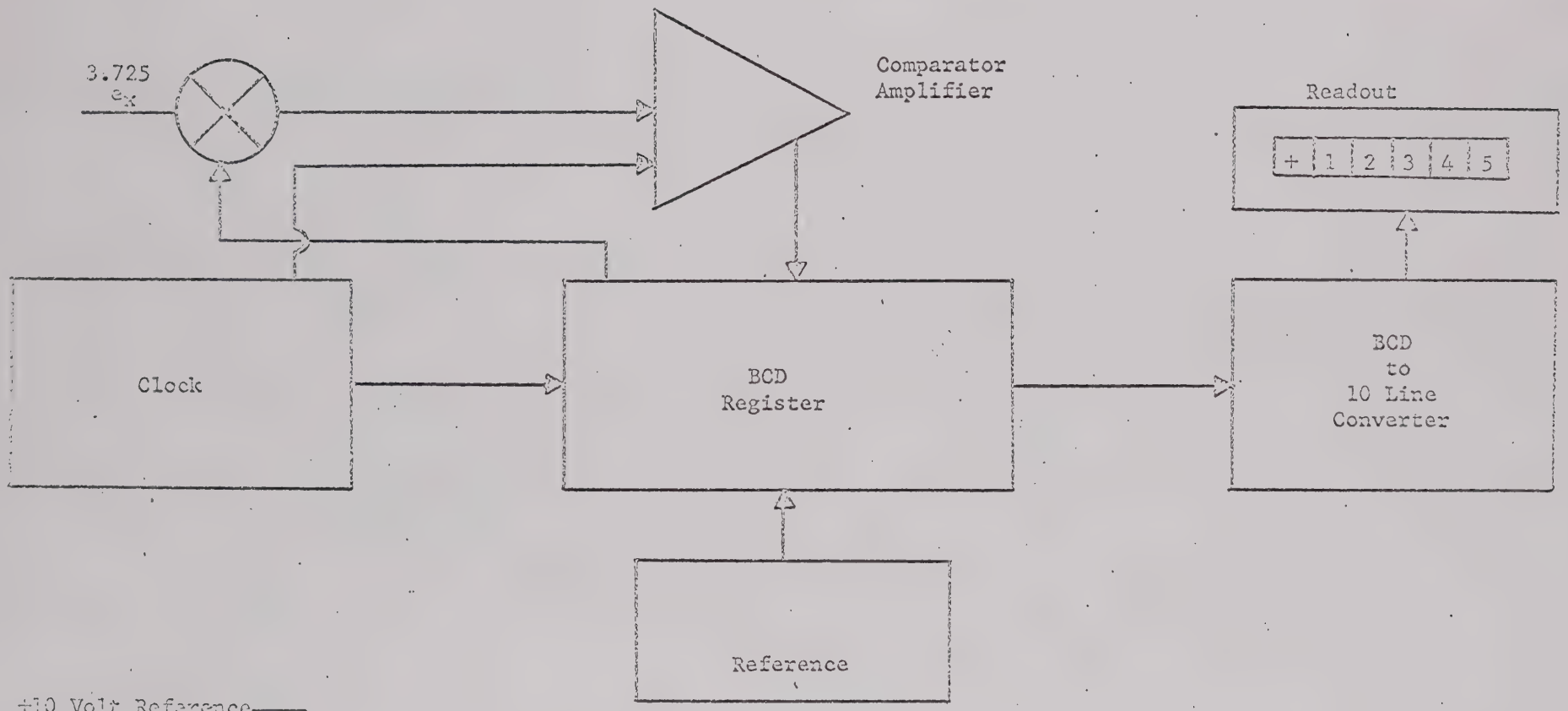
POTENTIOMETRIC (CONTINUOUS BALANCE) (TRACKING) LOGIC



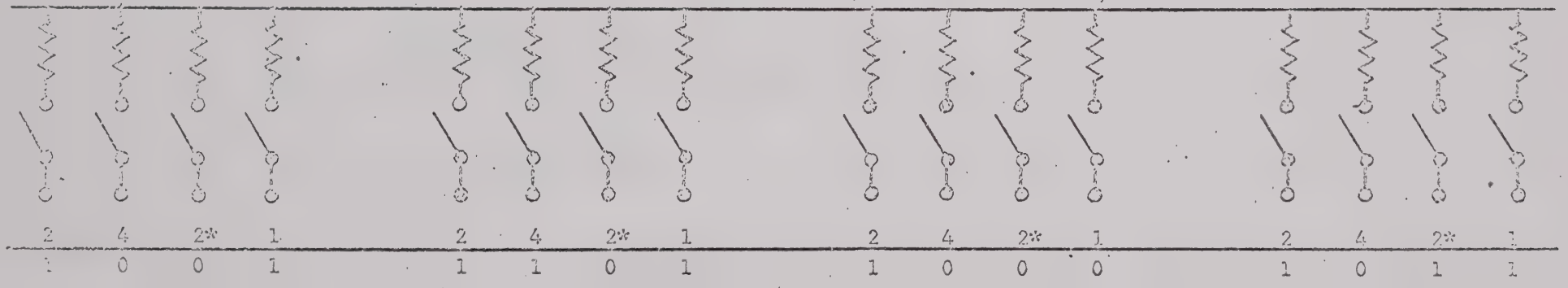
VOLTAGE TO TIME CONVERSION ( RAMP GENERATORS ) LOGIC



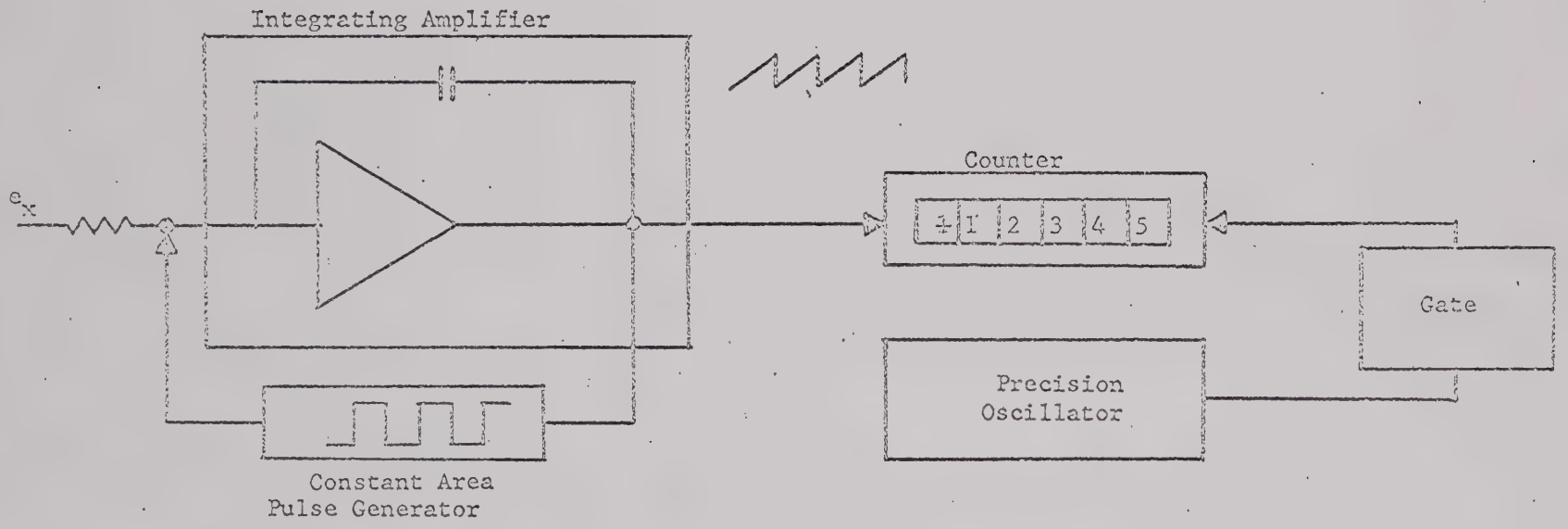
SUCCESSIVE APPROXIMATION (PRESCRIBED SEQUENCE) (ONE-PASS) LOGIC

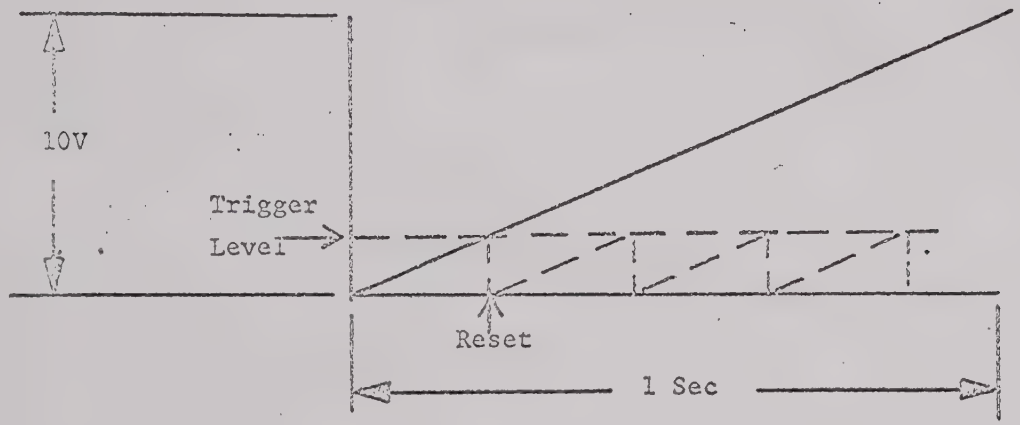


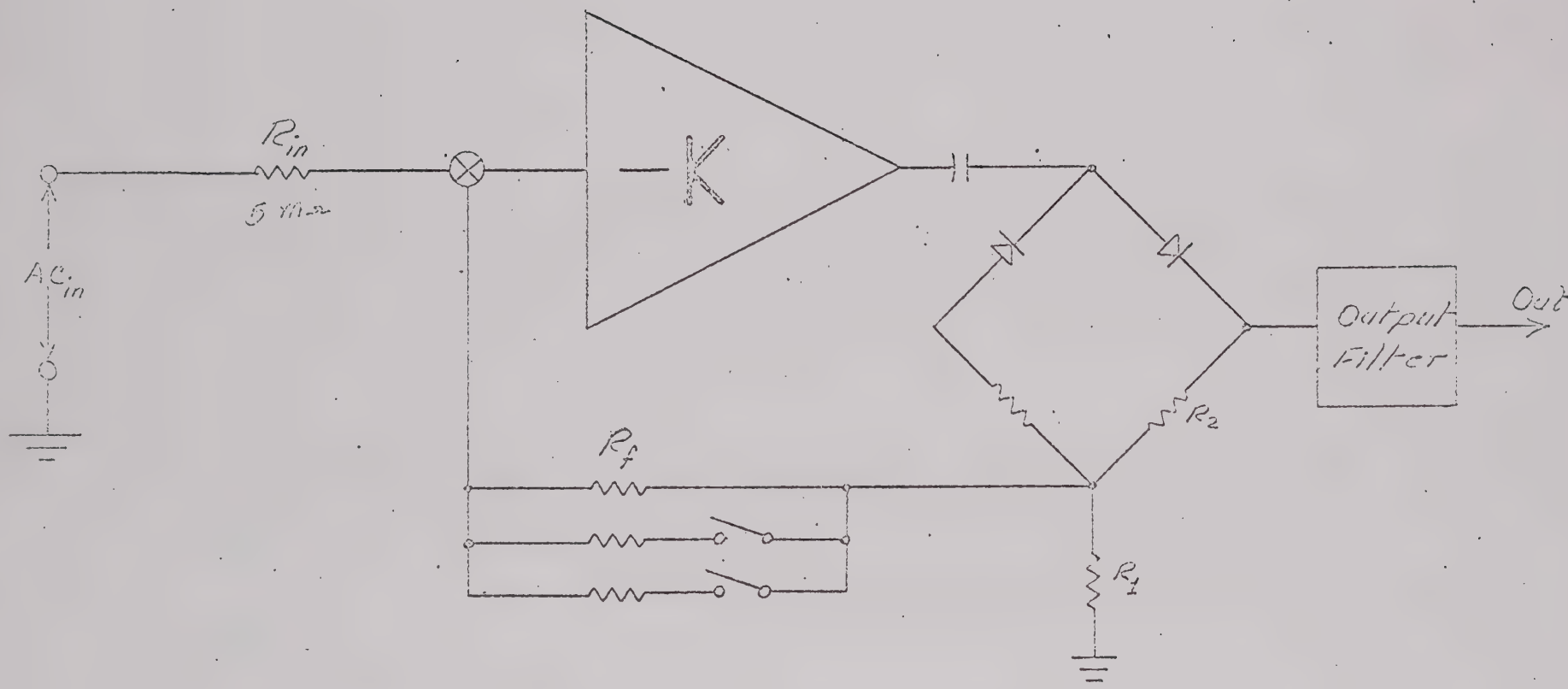

+10 Volt Reference



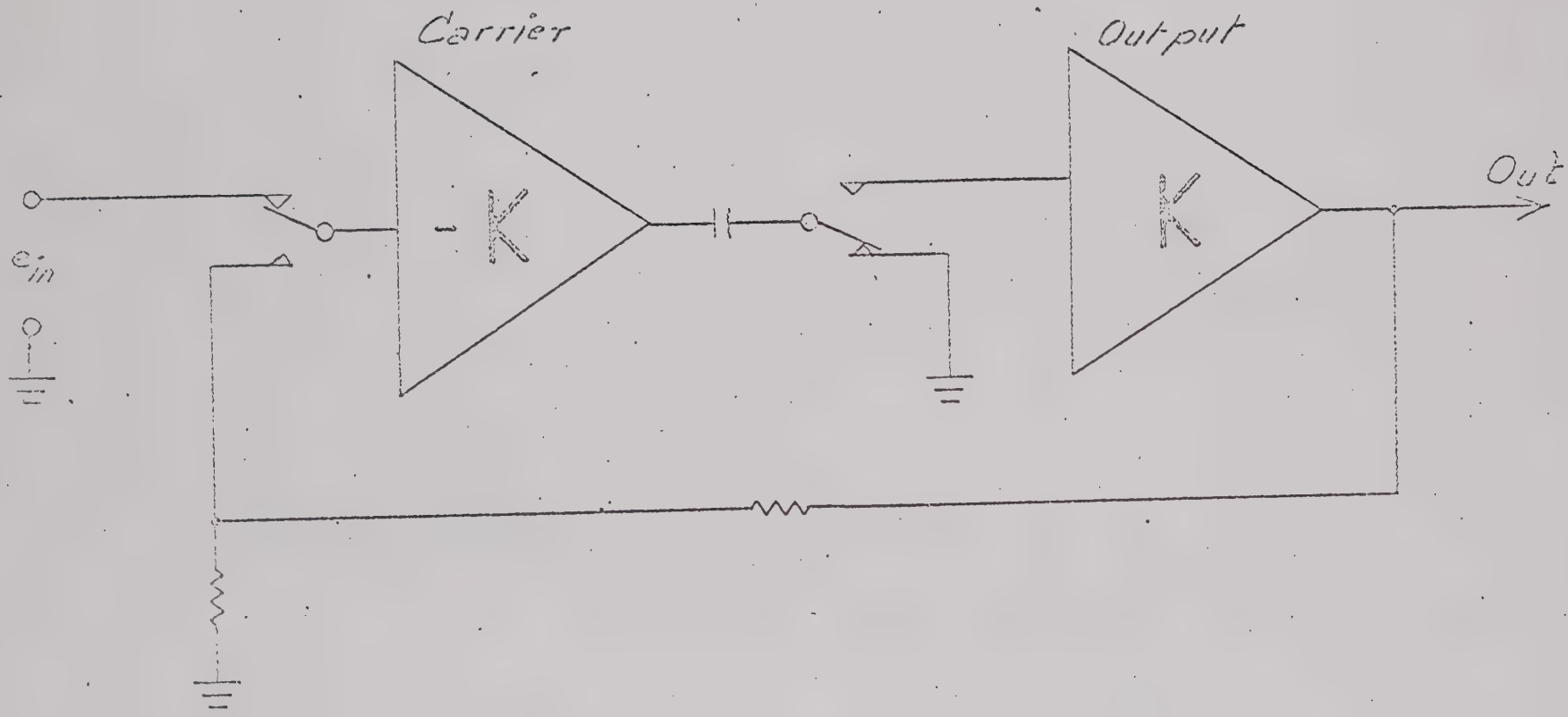
# VOLTAGE TO FREQUENCY (INTEGRATOR) LOGIC



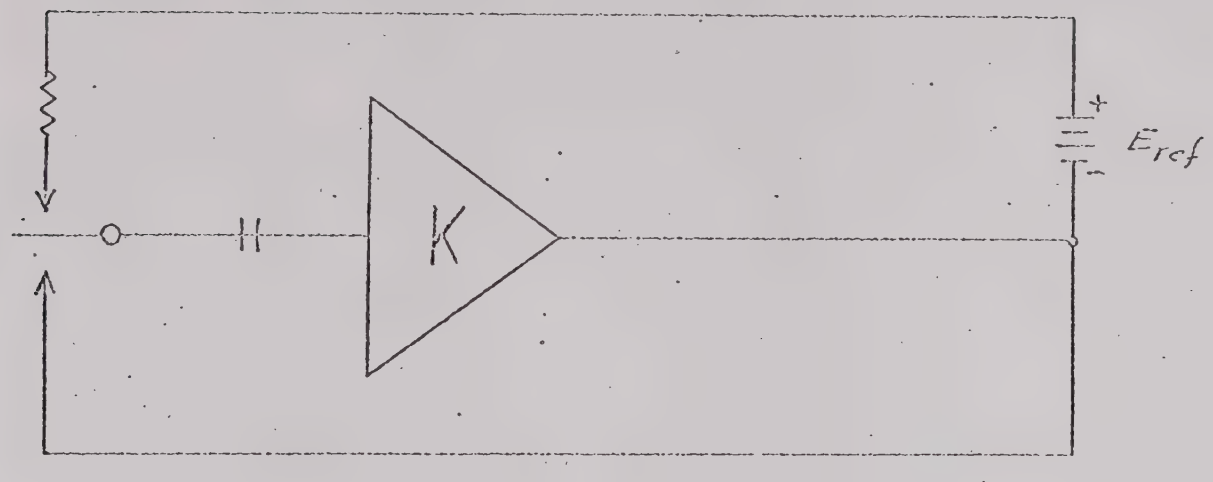



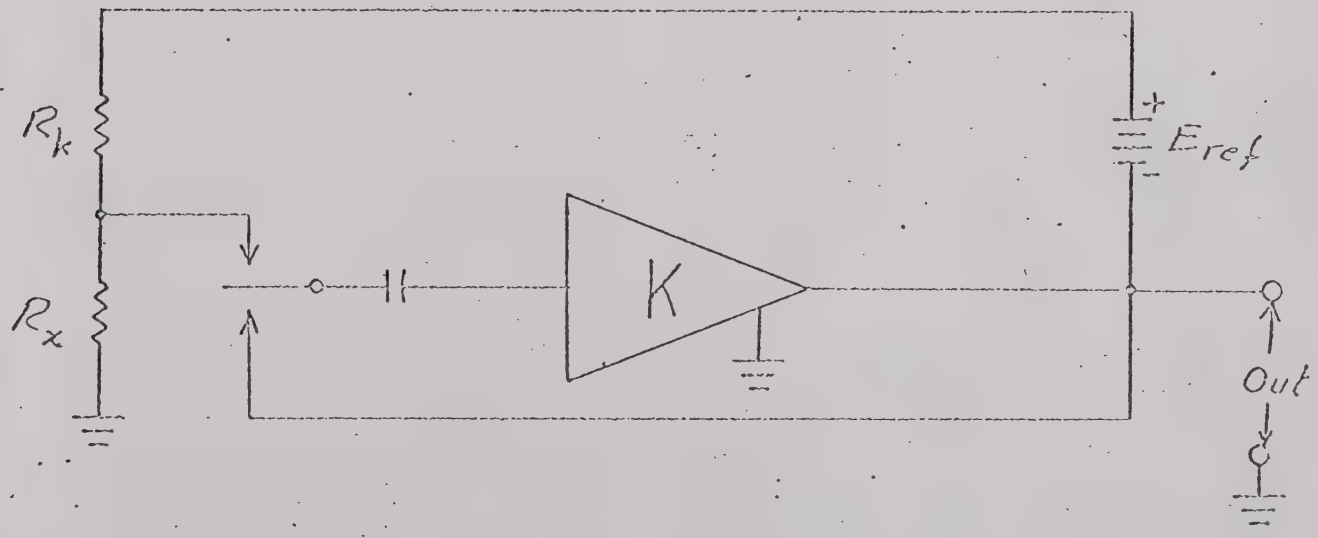

$R_{in}$
5 MΩ
$AC_{in}$
-K
$R_f$
$R_2$
$R_1$
Output Filter
Out

D.C. Pre-Amplifier

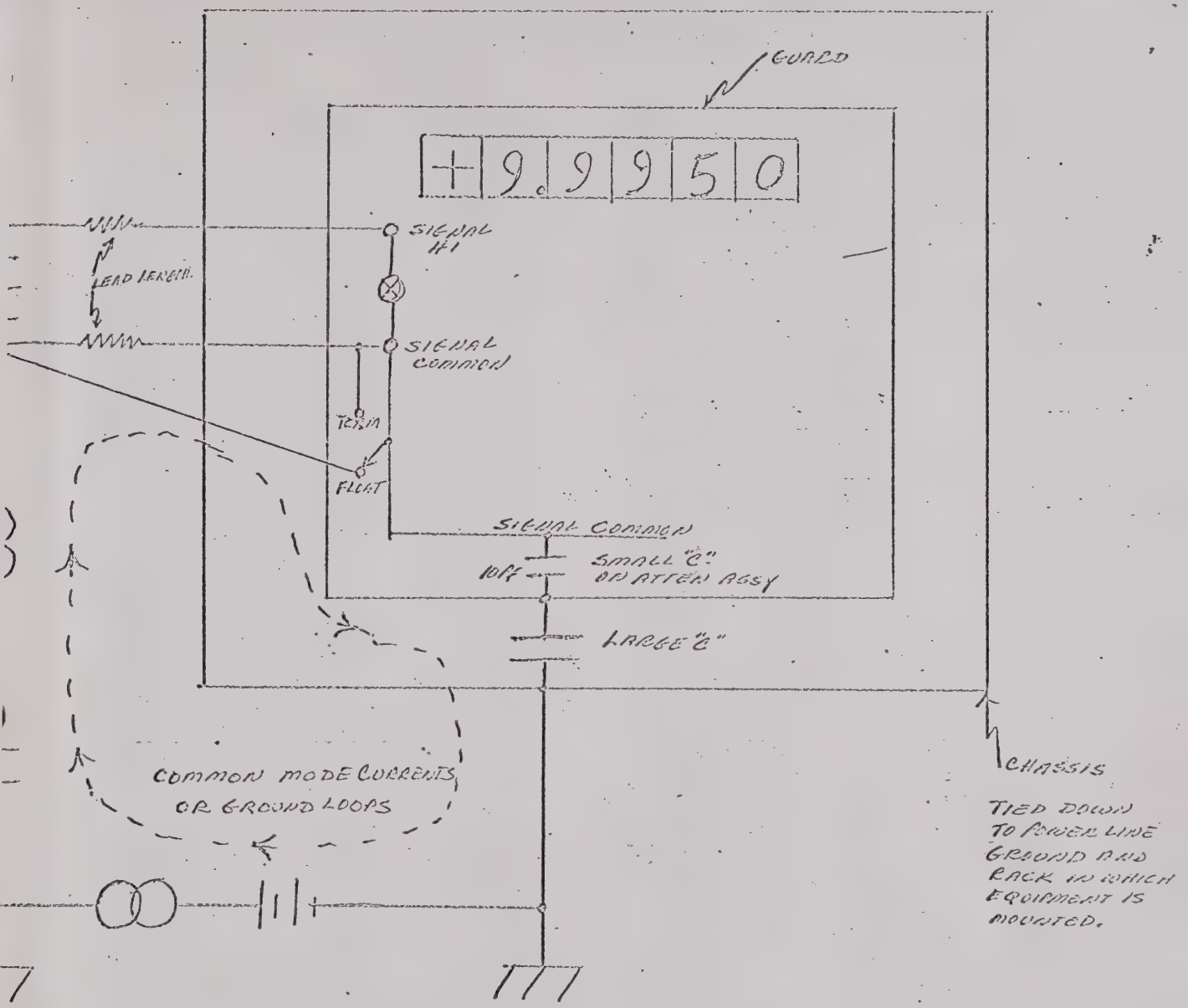


# Ohms Converter.



# P9000B SERIES COMMON MODE REJECTION (CMR)
## (BOX WITHIN A BOX CONSTRUCTION)




If we put 5V on top lead & 5V on bottom lead, we would have voltage common to both leads.

Since the voltage is common, (the same on both leads), the instrument should read nothing. The ability to read "nothing" in such instance is CMR.

CMR works as well with AC voltages which occur in synchronism as it does with DC voltages.

If we put a 60 HZ signal on the input of both leads and the peak of each signal is the same voltage at the same time, the instrument should read nothing.

That is how a CMR instrument can reject ground currents of 60 HZ.

Since the ground currents are (almost by definition) always in phase and common to both leads, the instrument simply doesn't see this common voltage. It only measures differences.

## ZENERS USED IN CIMRON PRODUCTS

| | Voltage | Tol. | Diss. | Test I | Z |
|---|---|---|---|---|---|
| 1N708A | 5.6V | 5% | 250MW | 25 MA | 3.6Ω |
| 1N710A | 6.8V | 5% | 250MW | 25 MA | 4.7Ω |
| 1N712 | 8.2V | 10-20% | 250MW | 25 MA | 6Ω |
| 1N712A | 8.2V | 5% | 250MW | 25 MA | 6Ω |
| 1N714A | 10V | 5% | 250MW | 12 MA | 8Ω |
| 1N716A | 12V | 5% | 250MW | 12 MA | 10Ω |
| 1N717A | 13V | 5% | 250MW | 12 MA | 11Ω |
| 1N718A | 15V | 5% | 250MW | 12 MA | 13Ω |
| 1N719 | 16V | 10-20% | 250MW | 12 MA | 15Ω |
| 1N720A | 18V | 5% | 250MW | 12 MA | 17Ω |
| 1N722A | 22V | 5% | 250MW | 4 MA | 24Ω |
| 1N722 | 22V | | 250MW | 4 MA | 24Ω |
| 1N723A | 24V | 5% | 250MW | 4 MA | 28Ω |
| 1N746A | 3.3V | 5% | 400MW | 20 MA | 28Ω |
| 1N750 | 4.7V | | 400MW | 20 MA | 19Ω |
| 1N752 | 5.6V | | 400MW | 20 MA | 11Ω |
| 1N938 | 9V | 5% | 500MW | 7.5 MA | 20Ω |
| 1N945 | 11.7V | 5% | 500MW | 7.5 MA | 30Ω |
| 1N957A | 6.8V | 5% | 400MW | 19 MA | 4.5Ω |
| 1N965A | 15V | 5% | 400MW | 8.5 MA | 16Ω |
| 1N969A | 22V | 5% | 400MW | 5.6 MA | 29Ω |
| 1N971B | 27V | 10% | 400MW | 4.6 MA | 44Ω |
| 1N972B | 30V | 10% | 400MW | 4.2 MA | 49Ω |
| 1N973B | 33V | 10% | 400MW | 3.8 MA | 58Ω |
| 1N3030B | 27V | 10% | 1 W | 9.5 MA | 35Ω |
| 1N3033A | 36V | 5% | 1 W | 7 MA | 50Ω |
| 1N3042A | 82V | 5% | 1 W | 3 MA | 200Ω |

## CD DIODES

| | | |
|---|---|---|
| CD-61 | $I_f$ 1V greater than 100 ma/ $I_r$ 75V less than 1 ua | Silicon |
| CD-62 | $I_f$ 1V greater than 100 ma/ $I_r$ 300V less than 6 ua | Silicon |
| CD-63 | $I_f$ 1V greater than 15 ma/ $I_r$ 30V less than 100 ua | Germanium |

## TRANSISTORS: Nearest Commercial Replacement

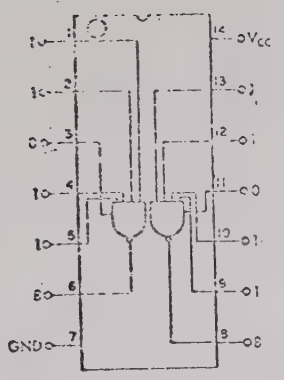
CT-20 2N697; CT-21 2N2222; CT-22 2N3114; CT-23 2N697;
CT-24 2N3114; CT-25 2N3114; CT-26 2N2222; CT-31 2N1131

Effective November 1, 1966

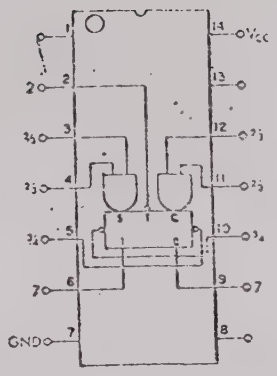
Valid from 0°C to +75°C
with $V_{CC}$ = 5.0 V ± 10%

TOP VIEWS

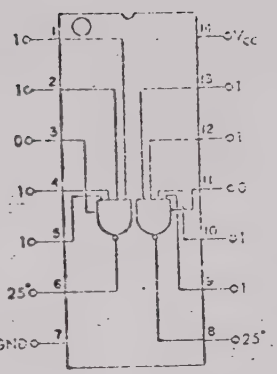
Numbers at end of terminals indicate loading.



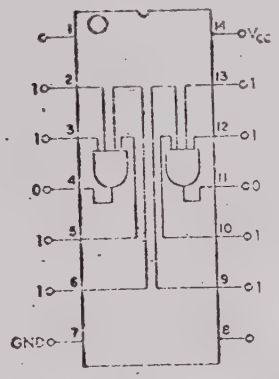
MC830P — Dual 4-Input Gate



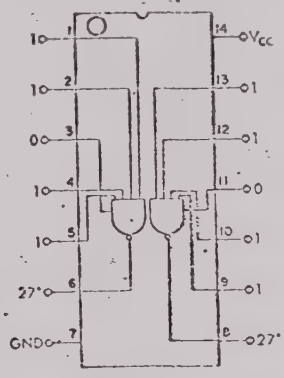
MC831P — Clocked Flip-Flop



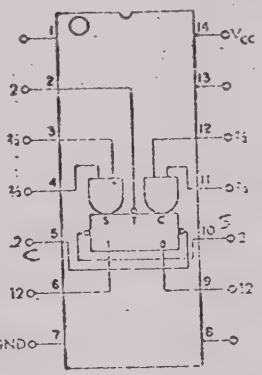
MC832P — Dual Buffer



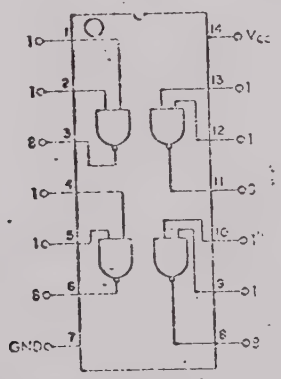
MC833P — Gate Expander



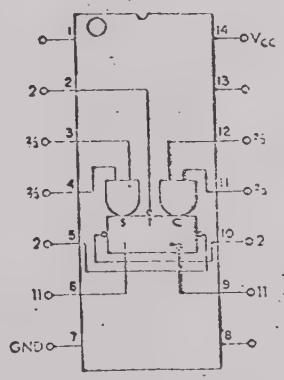
MC844P — Dual 4-Input Power Gate



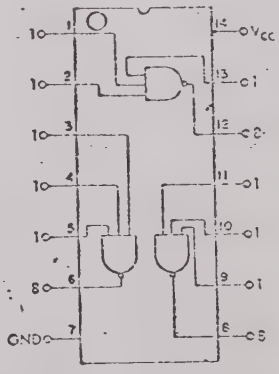
MC845P — Clocked Flip-Flop



MC846P — Quad 2-Input Gate



MC848P — Clocked Flip-Flop



MC862P — Triple 3-Input Gate

*See General Rules

The number of load circuits that may be driven from an output is determined by the input loading factor. The summation of input loading should not exceed the drive capability of the output.

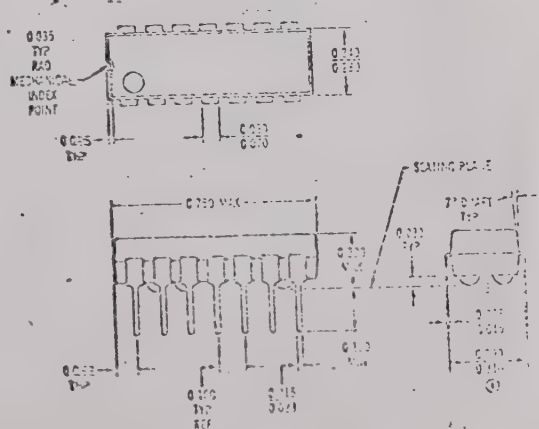
The outputs of the Dual 4 Input gate may be tied together to perform the wired-collector OR function. For each added gate subtract 1 unit fan-out. For six added gates only 5 unit loads need be subtracted.

The outputs of the Dual Buffer may not be tied together.

The outputs of the Dual Power Gate may be tied together to perform the wired-collector OR function.

An external load resistor should be utilized with the Dual Power Gate. At Vcc = 5.0 ± 0.5 V, values for the following output loads:

R
2 kΩ — 2 loads
1 kΩ — 4 loads
510 Ω — 6 loads




① Lead spacing tolerance non-cumulative
② Controlling dimension: inch

# TRUTH TABLES

## 1242* COUNTING
USED IN CIMRON SERIES 7600 & 4600

1 = true
0 = false

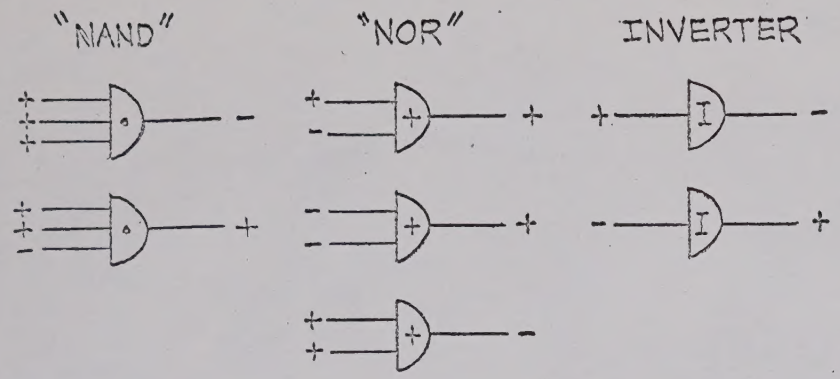
| DECIMAL | B.C.D 1 | 2 | 4 | 2* |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |
| 1 | 1 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 1 |
| 3 | 1 | 0 | 0 | 1 |
| 4 | 0 | 1 | 0 | 1 |
| 5 | 1 | 1 | 0 | 1 |
| 6 | 0 | 0 | 1 | 1 |
| 7 | 1 | 0 | 1 | 1 |
| 8 | 0 | 1 | 1 | 1 |
| 9 | 1 | 1 | 1 | 1 |

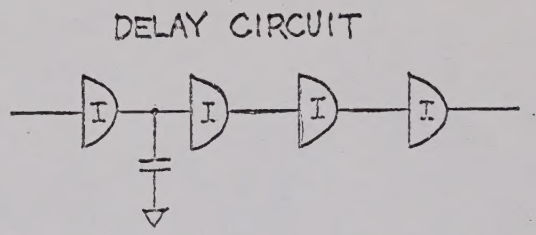
## 1248 COUNTING
USED IN CIMRON 6653

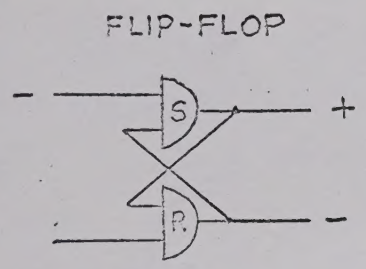
1 = true
0 = false

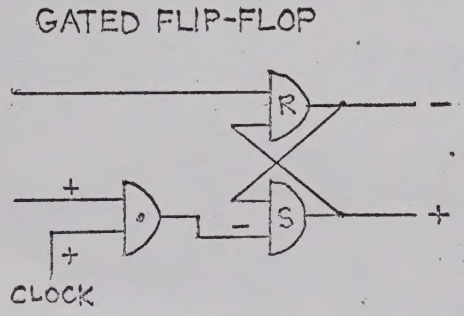
| DECIMAL | B.C.D. 1 | 2 | 4 | 8 |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |
| 1 | 1 | 0 | 0 | 0 |
| 2 | 0 | 1 | 0 | 0 |
| 3 | 1 | 1 | 0 | 0 |
| 4 | 0 | 0 | 1 | 0 |
| 5 | 1 | 0 | 1 | 0 |
| 6 | 0 | 1 | 1 | 0 |
| 7 | 1 | 1 | 1 | 0 |
| 8 | 0 | 0 | 0 | 1 |
| 9 | 1 | 0 | 0 | 1 |

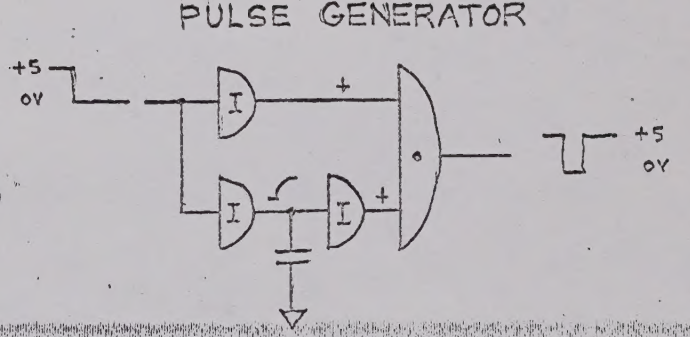
# CIMRON LOGIC CIRCUITS




Notes:
1. Generally, logic is 0V true
2. + INDICATES +5V
   − INDICATES 0V
3. Delay times with capacitive circuits ≈ 1ms/mfd
4. Nomenclature "NAND" & "NOR" dependent upon usage.

12-19-